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**Cover Photograph**: Common Otter
*Lutra lutra*
By Vikas Choudhari

# Editorial

## Threatened Birds of India: Need for immediate conservation action

In 1963, Sir Peter Scott, one of the founder-members of World Wildlife Fund (now World Wide Fund for Nature) suggested to the International Union for Conservation of Nature and Natural Resources (IUCN) to bring out a document on "threatened wildlife that includes definitions of degree of threats". Thus, the idea of Red Data books was conceived. The first loose-leafed spiral bound edition appeared in 1964, which was regularly updated as more species joined the list or more information was made available (Vincent 1966-1971). The second edition of this series was published in the late 1970s (King 1978-79). This book was reprinted in 1981 as ENDANGERED BIRDS OF THE WORLD: THE ICBP BIRD RED DATA BOOK, by Smithsonian Institution, Washington, USA. This book described 437 threatened subspecies and species of birds.

BirdLife (earlier International Council for Bird Preservation) is the official Listing Authority for Birds for the IUCN Red List and works closely with the IUCN Species Specialist Groups (SSGs). In 1985, the first regional bird Red Data Book of Africa and related islands was published (Collar and Stuart 1985); followed by the highly acclaimed BIRDS TO WATCH in 1988 (Collar and Andrew 1988). It was the first global list of 1,029 birds threatened with extinction. An updated version of this book was published in 1994 as BIRDS TO WATCH-2 (Collar *et al.* 1994) listing 1,111 species, including 171 species of India. Prior to this book, another regional Bird Red Data Book was brought out by BirdLife titled THREATENED BIRDS OF THE AMERICAS (Collar *et al.* 1992). In 2000, another landmark publication THREATENED BIRDS OF THE WORLD, which had a list of 1,186 species worldwide, and 123 species in India, was published (BirdLife International 2000). For the first time, Near Threatened species were also documented. The following year saw the publication of two volumes of THREATENED BIRDS OF ASIA (BirdLife International 2001) that document 323 globally threatened species found in Asia. Most worrying was that 41 species were Critical and 65 were Endangered, meaning that if nothing was done, these species would disappear in the next 5-10 years. This book also documents 317 Near Threatened species which are close to qualifying as globally threatened.

Since 2000, the BirdLife is maintaining a dynamic World Bird Database, which makes information on globally threatened birds available on the website (www.birdlife.org/datazone/species.index.html). This database is updated on an annual basis. In the latest version (uploaded on January 2009), 149 Indian bird species are threatened. This includes 14 Critical, 12 Endangered, 58 Vulnerable, 63 Near Threatened and two Data Deficient species. The Critical list also includes two supposedly extinct species: Himalayan or Mountain Quail *Ophrysia superciliaris* and Pink-headed Duck *Rhodonessa caryophyllacea*.

In 2005, Rasmussen and Anderton brought out two volumes of BIRDS OF SOUTH ASIA: THE RIPLEY GUIDE in which many subspecies were upgraded to species. In BirdLife there is a debate as to what level of a taxon: subspecies or species should the degree of threat be applied. At present, it is done chiefly at the species level. If Rasmussen and Anderton's (2005) classification is accepted, the list of threatened bird species in India increases, particularly those from Andaman and Nicobar; many of which would qualify for the Red Data List criteria as they have small insular populations facing numerous threats. For example, Rasmussen and Anderton (2005) suggest species status for the Andaman Teal *Anas albugularis*, considered until now as a subspecies of the widely distributed Grey Teal *Anas gibberifrons*. It is endemic to a few islands in Andaman, and the total population may not be more than 1,000 individuals (Vijayan *et al.* 2006), making it a high priority species for conservation in India. Similarly, the Andaman Barn Owl *Tyto deroepstorffi* was earlier considered as a subspecies of the globally distributed Common Barn Owl *Tyto alba* (Ali and Ripley 1983), but is now considered a species (Konig *et al.* 1999; Rasmussen and Anderton 2005). It is a resident on some islands in Andaman, with only five known specimens. An endemic species with a very small population makes the Andaman Barn Owl a high priority species for conservation in India.

In India, about 1,220 species of birds have been recorded (number depends on the classification we use) out of which 149 or *c.* 10% are threatened, which is not a very comfortable situation. Besides including most of the species in the Wildlife Protection Act (including 100 species in Schedule I: highest protection on paper), and banning bird trade since 1991, not much is being done to reverse the decline. There is no long-term bird species recovery programme, and the sanctuaries established, especially for threatened species (e.g., Sailana Lesser Florican Sanctuary, Karera Bustard Sanctuary, Rollapadu Bustard Sanctuary, Desert National Park and many more), suffer from administrative and financial neglect. Even the pitiable condition of the world-famous Keoladeo National Park has not stirred the attention of the Government. Its natural water supply has been cut off due to wrong administrative decisions, depriving the famous *jheels* of Keoladeo of water. Work to supply water by pipes to the Park has yet to start although the decision was taken five years ago after court order.

Although more than 600 protected areas of India provide habitat and some security to the threatened and non-threatened species, there are many species whose habitat is either not represented or under-represented in the PA network. For example, Yellow-throated Bulbul *Pycnonotus xantholaemus* is endemic to southern India. It is known from 80 localities, with all recent records from hills south of 16° N and east of 76° E. It is still locally common, but appears to be declining overall. Recent surveys of 75 localities found that it had totally disappeared from six historical sites, and at most occupied sites it is considered scarce (Thejaswi 2004). It lives in dry thorny jungles interspersed with large trees among broken stony hillocks, and deciduous forests. It is largely a sedentary resident; isolated populations are sometimes found in boulder-strewn hillsides or rocky outcrops with dense undergrowth in seemingly unfavourable landscape. As these boulder-strewn hillsides do not have charismatic mega-vertebrates (except for an occasional Leopard *Panthera pardus*), not many people are interested in protecting them.

Similarly, the Yellow Weaver or Finn's Baya *Ploceus megarhynchus* is endemic to northern India, where it is known from disjunct populations in the *terai* and from eastern Nepal to Assam. It has always been very locally distributed, and the disappearance of several colonies in recent decades indicates that it is declining. The recently discovered population in Nepal is estimated at <50 birds (BirdLife International 2008). It is reported from Haldwani and Pilibhet regions of northern India, and Manas in Assam, but everywhere in small numbers. It is still traded and smuggled for foreign market. It prefers marshes and wet areas with extensive stands of *Imperata*, *Narenga*, and *Saccharum* grasses, particularly those that are seasonally inundated, with well-scattered trees, and occasionally interspersed with patchy rice and sugarcane cultivation. Presently, BirdLife International (2008) has kept it in the Vulnerable category, but looking at its rapidly declining numbers, and scarcity of habitat, it has to be upgraded to the Endangered category.

Another example of conservation neglect is the Indian Skimmer *Rynchops albicollis*. It is found on larger rivers from Pakistan, through Nepal and India to Bangladesh and Myanmar. It was common in the 19th century in Myanmar, Laos, Cambodia and Vietnam, but there are very few recent records from Myanmar and none from Laos, Cambodia or Vietnam (BirdLife International 2008). It is uncommon in Pakistan (Roberts 1991) and Nepal (Inskipp and Inskipp 1991). In India also, it is becoming uncommon although still seen on larger north Indian rivers. Its major population could be in the Padma-Meghna delta in Bangladesh. Its total global population is estimated at 6,000-10,000 individuals (BirdLife International 2001, 2008).

In India, it is mainly found in north India, from Punjab (rare) through Uttar Pradesh, Madhya Pradesh and Bihar to West Bengal, extending up to Orissa (Chilika) and the Brahmaputra. Possibly a separate population is in Narmada, Mahanadi, Tapti, Godavari, and Krishna rivers in Andhra Pradesh and Orissa. As a winter migrant, it is reported from Saurashtra and the western coast of Gujarat and Maharashtra. It is not recorded south of about 16° N (Ali and Ripley 1983). It occurs primarily on larger, sandy, lowland rivers, around lakes and adjacent marshes, and in the non-breeding season, estuaries and coasts. It breeds colonially on large, exposed sand-bars and islands. Here the problem comes. Most of the river islands, even temporary sandbanks, are now occupied by man and his animals (dogs, cats, cattle) and House Crows *Corvus splendens*, which are seen around any human settlement. Sudden release of water from dams inundates the islands or more often, withdrawal of excessive water expose the river islands to ground predators as a result of which the Indian Skimmer faces nesting failure year after year. Even its main nesting river, the Chambal, is now under increasing threats of withdrawal of water despite being a Sanctuary!

Among the threatened Indian birds, some have not been seen for many decades. For example, the Manipur Bush-quail *Perdicula manipurensis* was last seen in 1932, and now in 2006 in Manas Tiger Reserve, Assam (Anwaruddin Choudhury *pers. comm.*, 2006). It is endemic to north-east India and probably Bangladesh (extinct?). Not much is known about this diminutive and shy bird of tall damp grasslands. No attempt is being made to even know its current distribution. Another example is Masked Finfoot *Heliopais personata*, a bird of mangrove and wetlands in dense forests. This bird has not been seen for many years in India, except for a stray record from Coringa Sanctuary in Andhra Pradesh. During the Annual Waterfowl Count from 1997 to 2007 in Asia (Li *et al.* 2009), it was recorded only from 14 sites, none in India. It was reported from Sundarbans of Bangladesh, twice in 1990 (one bird) and 2002 (two birds), so it is likely to be present on the Indian side also.

In 2004, the Indian Bird Conservation Network, BNHS, BirdLife International, and Royal Society for the Protection of Birds released a list of 446 sites that qualify the global criteria as Important Bird Areas (Islam and Rahmani 2004). Nearly 200 of these IBAs do not have any legal support in the form of Protected Areas established under the Indian Wildlife Protection Act. Many of these IBAs qualify for a Park or Sanctuary status, and the rest can be declared as Community or Conservation Reserves. Although more than 600 Indian PAs provide protection to threatened bird species, if we add the 200 non-protected IBAs in this category, all the species which need site-based approach of protection will be in saved. For species such as the Great Indian Bustard *Ardeotis nigriceps*, Sarus Crane *Grus antigone*, Greater Spotted Eagle *Aquila clanga*, which live in a larger landscape, general environmental protection will be required.

The Government of India has to look beyond Project Tiger and the existing protected area network if it is sincere in protecting all biodiversity, including many threatened bird species which find no 'god father' or do not provide commercial incentive to some as the tiger conservation business does.

Asad R. Rahmani

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# ASPECTS OF THE ECOLOGY OF SMOOTH-COATED OTTER *LUTROGALE PERSPICILLATA* GEOFFROY ST.-HILAIRE, 1826: A REVIEW

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Of the thirteen species of Otters reported worldwide four are found in Asia, and India is home to three species. The Smooth-coated Otter *Lutrogale perspicillata* is the most common of Asian Otters, being distributed throughout India from the Himalayas southward. It prefers habitats such as large rivers, lakes and swamps and tends to compete for resources with the Small-clawed Otter *Aonyx cinereus* and Eurasian Otter *Lutra lutra* when all the three species occur sympatrically. The species is listed as Vulnerable by the IUCN and is on Appendix II of the CITES and Schedule II (Part II) of the Indian Wildlife (Protection) Act, 1972. While some measure of research has been established, Otter conservation efforts in India are lagging far behind those in Europe and the rest of the world. This review summarizes the current conservation status and aspects of ecology of the Smooth-coated Otter, suggesting areas/aspects of future research particularly with respect to India. The need for such a review arises from a necessity to direct further research efforts towards wetlands and freshwater biomes in general, and those of Otters in particular, and also to meet demands for conservation management.

**Key words**: Smooth-coated Otter, *Lutrogale perspicillata*, ecology, review, conservation management, India

## INTRODUCTION

Otters are semi-aquatic members of the Mustelidae family, and as high-order carnivores at the top of their small niche eco-systems their presence serves as an important biological indicator of wetland quality (Sivasothi and Burhanuddin 1994). Phylogenetically, the Otter family tree dates to the Miocene era, with Otter-like forms represented by genus *Mionictis*, inhabiting the Earth 20 million years ago (Hwang and Larivie're 2005). Of the 13 species of Otters worldwide, Sea Otter *Enhydra lutris* and Marine Otter *Lutra felina* are restricted to marine environments and the rest eleven inhabit mostly freshwater habitats (Estes *et al.* 1982). Four species of Otters are reported from Asia (Kruuk 2006): Hairy-nosed Otter *Lutra sumatrana*, Eurasian Otter *L. lutra*, Smooth-coated Otter *Lutrogale perspicillata*, and Small-clawed Otter *Aonyx cinereus*; of these the last three are found in India (Pocock 1941; Mason and Macdonald 1986; Kruuk 2006). The Smooth-coated Otter is distributed throughout the country from the Himalayas southward, but the Eurasian Otter and the Small-clawed Otter are restricted to the Himalayas, to the north of the Ganges and to southern India. Occurrence of all three species has been reported from north-east India and the Western Ghats (Hussain 1999).

Otters in general are becoming increasingly rare outside of national parks and wildlife sanctuaries, being threatened in many areas and that habitat destruction and poaching pose as a major threat as compared to other disturbances (Nawab 2007). The status of Otters in India is feebly documented and most of the distributional records are largely subjective or are based on chance observations, the results remaining inconclusive and consequently no concrete database exists for monitoring Otter population trends. This review summarizes the current conservation status and aspects of ecology of the Smooth-coated Otter *Lutrogale perspicillata* suggesting areas/aspects of future research on the species particularly with respect to India.

### Species profile

*Lutrogale* is from the Latin *lutr* meaning Otter, and *gale* meaning weasel or cat. The specific name *perspicillata* is Latin for conspicuous (Borror 1960). *Lutrogale* is known from the early Pleistocene of Java (McKenna and Bell 1997). The genetic structure of *Lutrogale perspicillata* is 2n=38, with a fundamental number of 62 (van Zyll de Jong 1987). The Otter may weigh up to 11.4 kg, the total length ranging between 1,067-1,300 mm (Harrison and Bates 1991; Foster-Turley 1992). In its external characters the Smooth-coated Otter is characterized by a very smooth, sleek pelage (Francis 2001). Upper lip to the edge of the rhinarium, cheeks, sides of the neck and throat are whitish or grey (Pocock 1941; Tate 1947). The underfur and guard hairs are 8 mm and 12 mm in length respectively. Muzzle is not spotted and the rhinarium is bare, dusky with peaked upper margin (inverted V-shaped). Vibrissae are white, <90 mm in length and well-developed. Eyes and ears are small. Tail is flattened, limbs are short, strong, and the fore and hind paws are large and well-webbed (Harrison 1968).

### Distribution and Conservation Status

The distribution of Smooth-coated Otter is disjunct (Fig. 1) being distributed throughout southern Asia (Hwang and Larivie're 2005). Of the three subspecies, *Lutrogale*

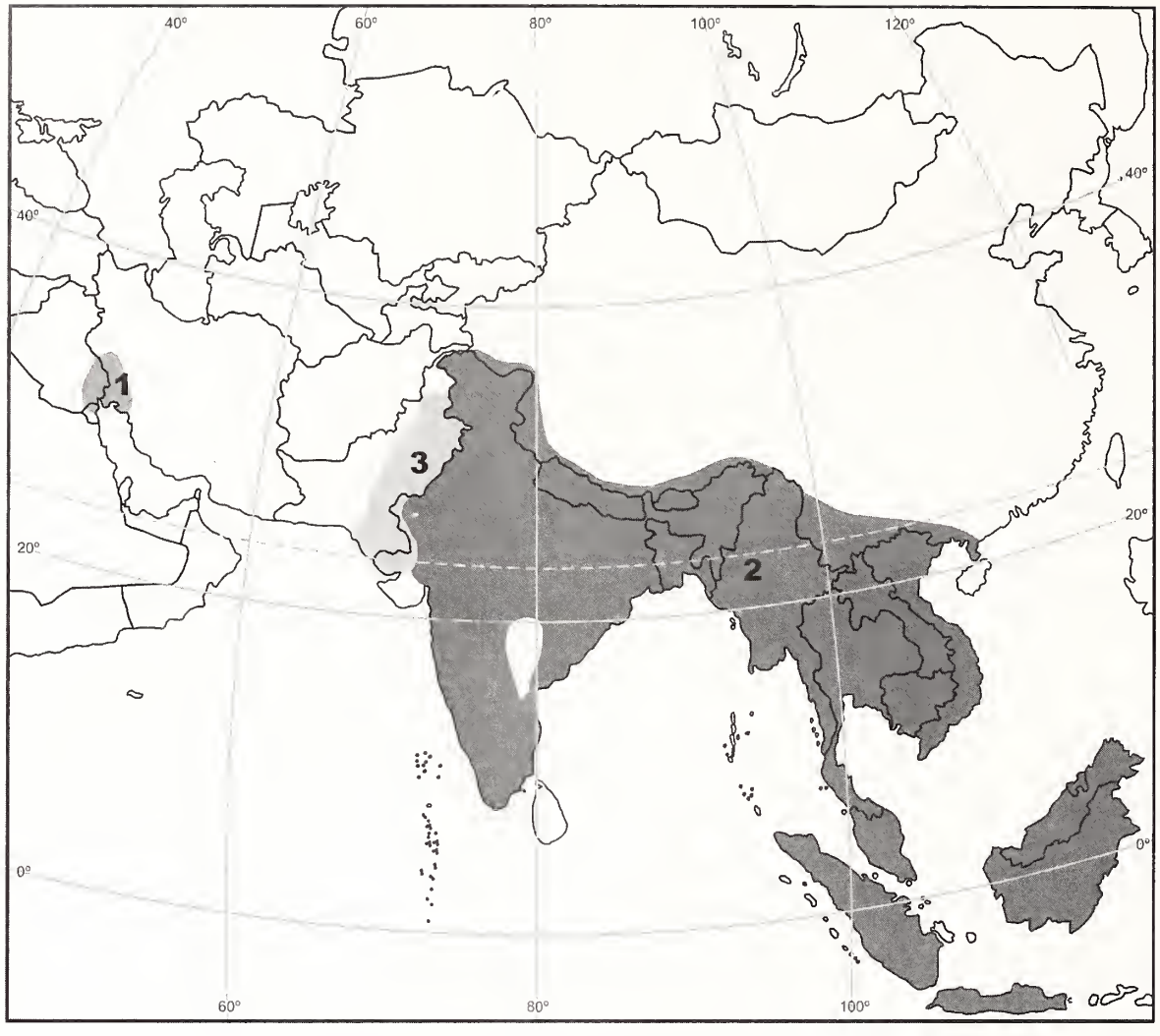


Fig. 1: Distribution of Smooth-coated Otter *Lutrogale perspicillata* in Asia
1. *L.p. maxwelli*, 2. *L.p. perspicillata* and 3. *L.p. sindica*.
*Source*: Hwang & Larivie're (2005)

*perspicillata perspicillata* has a wider distribution and occurs in most of India, Nepal, east to south-western Yunnan, Indo-China, and south to Malaysia, Sumatra, and Java. *L.p. sindica* occurs in Pakistan (Hwang and Larivie're 2005) and is also reported from India (Pocock 1941). *L.p. maxwelli*, whose current status is uncertain, is reported from the marshes of southern Iraq (Mason and Macdonald 1986). In India, the Smooth-coated Otter in most of its range is sympatric with the Small-clawed Otter *Aonyx cinereus*, and sometimes also with the Common Otter *Lutra lutra* (Foster-Turley 1992). The Smooth-coated Otter is under Schedule II (Part II) of the Indian Wildlife (Protection) Act, 1972, and is listed as Vulnerable (VU) by the IUCN and is on Appendix II of the CITES.

**Habitat use**

Otter habitat appears to be extremely variable, however, more accurately it can be characterised as a narrow strip on either side of the interface between water and land by being to some extent one-dimensional, i.e., linear (Kruuk 2006). Stumpf and Mohr (1962) asserted that the expression of home range in terms of linear units is justifiable for a number of species, including Otters, and home ranges of Otters living in riverine habitat are estimated in linear units (Erlinge 1967; Melquist and Hornocker 1979). Similarly, the length of coastal shoreline has often been used to quantify the home range of Otters living in marine (Kruuk and Hewson 1978; Arden-Clarke 1986) and Lacustrine habitats (Erlinge 1967). The linearity of the habitat makes confrontation inevitable, affecting competition for resources. In such case, Kruuk (2006) has suggested random dispersion, with tolerance between individuals by some kind of group territorial system among Otters. Moreover, there appear to be differences in the spatial organisation in different areas, and there is variation in group size and range size, which can be

explained in terms of adaptation to environmental characteristics in which resource dispersion hypothesis plays an important role (Macdonald 1983; Carr and Macdonald 1986).

*Lutrogale perspicillata* is essentially a plains' Otter preferring low elevations. In the Indian subcontinent they are adapted to live in north-western desert, dry zone of central India and the Deccan plateau (Prater 1998). In general, they occur along the large rivers and lakes, Peat swamp forests, mangrove forests along the coast and estuaries, and even use rice fields for foraging (Shariff 1984; Foster-Turley 1992; Melisch *et al.* 1994; Sivasothi and Burhanuddin 1994). When occupying saltwater areas, they require freshwater nearby (Wayre 1978; Kruuk *et al.* 1994). When it occurs sympatrically with other Otter species it tends to use larger water bodies, and does not occur on small streams and irrigation canals (Wayre 1978). As reported for Eurasian Otter *Lutra lutra*, reservoirs are used; they form artificial habitats (Ruiz-Olmo *et al.* 2005) and usually serve as travel lanes (Sheldon and Toll 1964). In India, Anoop and Hussain (2004) recorded presence of *Lutrogale perspicillata* along the shallower and narrower regions of the lake in Periyar Tiger Reserve, while conversely, Nawab (2007) recorded that the Ramganga reservoir in Corbett Tiger Reserve; with steep shore lines, deep water, absence of escape cover and presence of mugger (major predator of Otters) was found unsuitable for Smooth-coated Otters. Along the larger perennial water bodies in India, Smooth-coated Otter show preference for rocky and sandy stretches in all the seasons, since these stretches provide sites for denning and grooming. River stretches with bank side vegetation are favoured as they provide escape cover while travelling or foraging (Nawab 2007). Hussain and Choudhury (1995) recorded in Chambal river that an adult female with cubs defended a home range of 5.5 km while for an adult male it was estimated as approximately 17 km. Also, the home range of the adult male overlapped extensively with that of several female home ranges. Studies in northern India recorded smaller home ranges of Smooth-coated Otters. This suggests that Otters tend to adapt to their available environment in patchy and disturbed sites, restricting their movement (Nawab 2007).

**Food and feeding habits**

Diet and feeding habits of Otters is one aspect of their ecology that has been studied widely in different parts of the world (summaries in Mason and Macdonald 1986). Tooth morphology of the fossils suggests that older forms of *Lutrogale* fed mainly on shellfish (Willemsen 1986). Smooth-coated Otters have generally been described as fish specialist (Haque and Vijayan 1995; Anoop and Hussain 2005; Nawab 2007). During a study on the feeding ecology of this species in Corbett Tiger Reserve, northern India, four prey categories were identified from 499 spraints analysed; fish (84%) was the most frequently occurring item and also formed the bulk (97.27%) of the diet (Nawab 2007). Prater (1998), Foster-Turly (1992) and Hussain (1993) have established that the exploitation of secondary prey, especially in winter, such as shrimp/crayfish, crab and insects, and other vertebrates such as frog, mudskippers, birds and rats may be a strategy for meeting additional energy requirements for thermoregulation and for rearing pups. Smooth-coated Otter are strong swimmers and hunt in groups (Kruuk *et al.* 1994), preferring shallow and placid waters (Nawab 2007). When fishing they travel in a V-formation going upstream (Helvoort *et al.* 1996). Most foraging activity occurs in water and small fish are swallowed whole (Helvoort *et al.* 1996), but large fish are taken to shore (Ansell 1947). Spraint sites of Smooth-coated Otter occur on small rocks, sand banks and large boulders 1-3 m above water level and these sites often smell of rotten fish (Kruuk *et al.* 1993; Nawab 2007). Shariff (1984) recorded these animals to roll and rub on grassy areas, especially after defecation and to sometimes rest on bare sand. When groups of Smooth-coated Otter forage, the commotion may attract birds which benefit from the smaller fish that flee into shallow water (Kruuk *et al.* 1993; Helvoort *et al.* 1996). However, these interactions may be detrimental to Otters because birds attempt to steal fish (Helvoort *et al.* 1996). Studies on the dietary habits of mugger in Andhra Pradesh have revealed the presence of Otter furs in the scats of Indian marsh crocodile (Kumar *et al.* 1995); and alternately crocodile hatchlings can also be potential prey for Otters (Kumar 1993).

**Reproduction**

In captivity, Smooth-coated Otters are known to attain sexual maturity at twenty-two months and mate during August to November. Males are polygamous mating with up to four females (Desai 1974); copulation occurs in water lasting <1 min (Yadav 1967; Badham 1973) followed by prolonged playful bouts between partners. The gestation period varies from 60 to 62 days (Yadav 1967; Desai 1974; Naidu and Malhotra 1989) and a litter of 2-5 pups is born. Smooth-coated Otters often dig their own breeding dens (Badham 1973; Wayre 1978; Nawab 2007) and maintain small family groups of a mated pair with up to four offsprings from previous seasons (Wayre 1978). Captive studies suggest that the longest lifespan of Smooth-coated Otters is around 20 years and 5 months (Medway 1969; Acharjyo and Mishra 1983; Chakrabarti 1993).

**Threats**

Developmental activities such as construction of dams adversely affect Otter populations due to the reduction of water flow downstream denying access to prey and den sites (Ruiz-Olmo *et al.* 1991). Randell and Leatherwood (1994) have commented on the changes in prey dynamics, which are the consequences of waterway obstruction, such as less diversity and small biomass of prey in impoundment upstream of dams due to lowered nutrient availability and reduction in prey due to blocked migratory routes. In Europe, studies on Otters (Jimenez and Lacomba 1991) have revealed that infrastructural activities can cause extinction of Otter populations from the lower and upper reaches of a river system and that the species gets confined to the less productive stretches. Otters also require undisturbed bank side cover for their survival. The depletion of sand from banks decreases the number of sites where Otters can groom and bask (Anoop and Hussain 2004; Nawab 2007).

Otters are often in direct conflict with fishermen who view them as vermin or competitors for fish and kill them (Foster-Turley 1992). Unimpeded fishing practices using destructive methods, such as dynamiting, *ghan* or hammering and use of Ichthyotoxic plants to poison fish forms a major form of disturbance to Otters. This leads to indiscriminate killing of large number of fish (juvenile as well as brood fish) that adversely affects the population of fish as well as the water quality (Nawab 2007).

Wildlife conservation efforts in India and concern about illegal wildlife trade has largely been concentrated on large fauna such as tigers, leopards, elephants and rhino amidst much public outcry to protect these species. In spite of the general awareness of the trade in wildlife and its derivatives in India, there is little information on the extent and prevalence of illegal trade in Otter skins, and consequently the threats to the species (Nawab and Gautam 2008). Otters are hunted for their pelts, meat, fat and other body parts (Meena 2002). Seizure figures of wildlife offences in the country reveal that 20-30% of the fur trade is in Otter skins. The main markets are Kanpur, Lucknow, Kota, Kolkata, Bengaluru and Delhi. The Otter fur trade, which is practiced in many parts of the world, routes out via Nepal and Bangladesh to importing countries (Hanfee and Ahmad 1999). Nomadic hunting tribes in India, such as *Gilhara*, *Badiya* and *Jogis* are known to regularly kill Otters for their skin and flesh (Walia 2001; Nawab 2008). Tribals and traditional practitioners of *Ayurveda* in Andhra Pradesh are known to use Otter blood as a cure for epilepsy (Nagulu *et al.* 1999).

**Research and Conservation Advocacy**

In Asia, research on Otters date backs to 1988 when the first International Symposium on Asian Otters was held in India (Foster-Turley *et al.* 1990; Hussain 1999). Since then major doctoral works carried out on Smooth-coated Otter include: northern India (Nawab 2007), central India (Hussain 1993) and southern India (Satyanarayana 1997). A few short-term studies have also been conducted (Nagulu *et al.* 1997; Anoop 2001; Shenoy 2003; Perinchery 2008). Surveys to determine where Otter populations still exist and where greater habitat protection measures are necessary are the first step. Parallel efforts involve research into such areas as the ecological requirements of Otters, their reproductive biology, and the effects of deleterious pollutants in the food chain. Practical habitat management activities ranging from basic field research programmes, to planning and advising Government in undertaking large-scale development projects on species specific habitat management (Hussain 1999). Even more perplexing than the lack of ecological information about Otters is an apparent lack of interest in Otters in India (Nawab 2006); hence awareness generation towards the plight faced by Otters and their ecological and aesthetic importance to aquatic environments should form an integral part of such studies to reinforce sympathetic attitude from the general public.

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# A SURVEY OF FRESHWATER FISHES OF ANDAMAN ISLANDS

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A survey of the freshwater fish community was conducted in five large islands of the Andaman archipelago. The objective of the study was to make a complete inventory of freshwater fishes and ascertain the status of fish species reported by Herre (1939). We have collected with cast nets and other fishing traps 2,403 fishes belonging to 33 species in 77 perennial streams and 1 perennial river. 17 species (11 native) were freshwater fishes. *Acentrogobius caninus* is reported here for the first time from the Andaman Islands and it is also a first reporting from Indian inland waters. Five species of freshwater fish have been introduced from mainland India deliberately or accidentally since Herre's survey. The new findings have indicated that more new species can be found in undisturbed regions particularly, the tribal reserves and areas that are inaccessible. However, many of the native species are threatened due to habitat loss and invasive species.

**Key words**: Andamans, freshwater fish, native species, new species, introductions, habitat loss, Jarawa Reserve

## INTRODUCTION

The Andaman and Nicobar Islands are regions of high biological diversity and endemism of many faunal groups. The region should be included with Western Ghats and Sri Lanka as one of the major biodiversity 'hot spots' of the globe (Myers 1990). However, due to lack of accurate inventories, information on many of the taxa found in these islands is inadequate (Pande *et al.* 1991), in particular, the freshwater fishes.

Nevertheless, there were some early contributions on freshwater fish fauna; most of these were fragmentary or restricted to a particular group. These were on diversity (Day 1870, 1875-1878; Hora 1925; Mukerji 1935; Sen 1975), diversity and distribution (Herre 1939, 1941), and a study on Gobiidae (Koumans 1940). Herre (1939) had recorded 112 species of freshwater and littoral fish, which is the most comprehensive work, so far. The present status of these fishes is not clear. Later studies on freshwater fishes of Andamans were compilations of previous surveys (Talwar 1990).

Therefore, considering the importance of this study, the major objectives were: (1) to make a complete inventory of the freshwater fishes in large islands of Andaman group, and (2) to assess the status of the freshwater fishes in comparison with Herre's study (1939).

## STUDY AREA

The study was conducted in North Andaman, Middle Andaman, South Andaman, Rutland and Little Andaman. The Andaman and Nicobar Islands lie between 6° 45'-13° 30' N and 90° 20' - 93° 56' E, off the east coast of India in the southern part of Bay of Bengal (Srinivasan 1986). The Archipelago comprises of several hundred islands extending over 800 km. Total geographic area of Andaman and Nicobar Islands is 8,249 sq. km of which Andaman group of islands covers 6,408 sq. km.

These islands have a tropical climate with temperatures ranging from 18 °C to 34 °C. The average annual rainfall from the South-West and North-East monsoons ranges from 2,300 mm in the Little Andamans in the South to 3,000 mm in Mayabundar near the North Andamans. The dry season ranges from January to April.

## MATERIAL AND METHODS

### Fish Sampling

We conducted a survey over a 3-year period from 2005 to 2008 in the Andaman Islands. A systematic sampling of the streams has been carried out for freshwater fish species. Streams were walked from downstream to upstream and fish were collected with cast nets of various sizes (2,540 mm x 7 mm and 2,032 mm x 10 mm) at regular interval. For very small fishes, we modified existing methods for collection, such as cloths and bottles. Cloth of sizes 1 m x 0.6 m and 1 m x 0.45 m were used as traps and placed in water near the periphery of the stream mimicking natural substratum. After a preset time the cloth was gently lifted up above water surface by holding it at four corners and fishes were collected. Similarly, plastic bottles were used to catch small fish species. The collected fishes were measured to standard length, weighed and species recorded. A total of 2,403 samples from 77 perennial hill streams and one perennial river have been collected.

Fish identification was carried out using keys developed by Koumans (1953), Masuda *et al.* (1984), Talwar and Jhingran (1991), Pethiyagoda (1991), Kottelat *et al.* (1993) and Jayaram (1999), and with help of taxonomy experts from the Zoological Survey of India at Chennai.

## RESULTS

### Fish Diversity

A total of 2,403 individuals of 33 species belonging to 20 families and 29 genera (Table 1) were collected from the streams of North Andaman, Middle Andaman, South Andaman, Rutland and Little Andaman (Fig. 1).

**Table 1**: List of species grouped into families compared with Herre's list

| Family | Species | Herre's List |
|---|---|---|
| Gobiidae | *Glossogobius giuris* (Hamilton-Buchanan) | ✓ |
| | *Sicyopterus microcephalus* (Bleeker) | ✓ |
| | *Sicyopterus* sp. (Gill) | × |
| | *Awaous grammepomus* (Bleeker) | ✓ |
| | *Stenogobius gymnopomus* (Bleeker) | × |
| | *Redigobius tambujon* (Mukerji) | × |
| | *Acentorgobius caninus* (Valenciennes) | × |
| | *Schismatogobius* sp. (de Beaufort) | × |
| Aplocheilidae | *Aplocheilus panchax* (Hamilton-Buchanan) | ✓ |
| Channidae | *Channa orientalis* (Bloch & Schneider) | ✓ |
| | *Channa striatus* (Bloch) | × |
| Cyprinidae | *Parluciosoma daniconius* (Hamilton-Buchanan) | ✓ |
| Heteropneustidae | *Heteropneustes fossilis* (Bloch) | × |
| Clariidae | *Clarias batrachus* (Linnaeus) | × |
| Anabantidae | *Anabas testudineus* (Bloch) | × |
| Cichlidae | *Oreochromis mossambica* (Peters) | × |
| Syngnathidae | *Microphis insularis* (Hora) | ✓ |
| Eleotrididae | *Ophioeleotris aporos* (Bleeker) | ✓ |
| | *Butis gymnopomus* (Bleeker) | × |
| | *Eleotris fusca* (Schneider) | ✓ |
| | *Ophiocara porocephala* (Valenciennes) | ✓ |
| | *Butis butis* (Hamilton-Buchanan) | ✓ |
| Megalopidae | *Megalops cyprinoides* (Broussonet) | ✓ |
| Kuhliidae | *Kuhlia marginata* (Bleeker) | ✓ |
| | *Kuhlia rupestris* (Lacepede) | × |
| Mugilidae | *Liza parsia* (Hamilton-Buchanan) | ✓ |
| Ambassidae | *Ambassis urotaenia* (Bleeker) | ✓ |
| Apogonidae | *Apogon hylasoma* (Bleeker) | ✓ |
| Scatophagidae | *Scatophagus argus* (Linnaeus) | ✓ |
| Leiognathidae | *Leiognathus equulus* (Forsskal) | ✓ |
| Gerreidae | *Gerres filamentosus* (Cuvier) | ✓ |
| Toxotidae | *Toxutes jaculator* (Pallas) | ✓ |
| Carangidae | *Caranx sexfasciatus* (Quoy & Gaim) | ✓ |

✓: recorded ×: not recorded

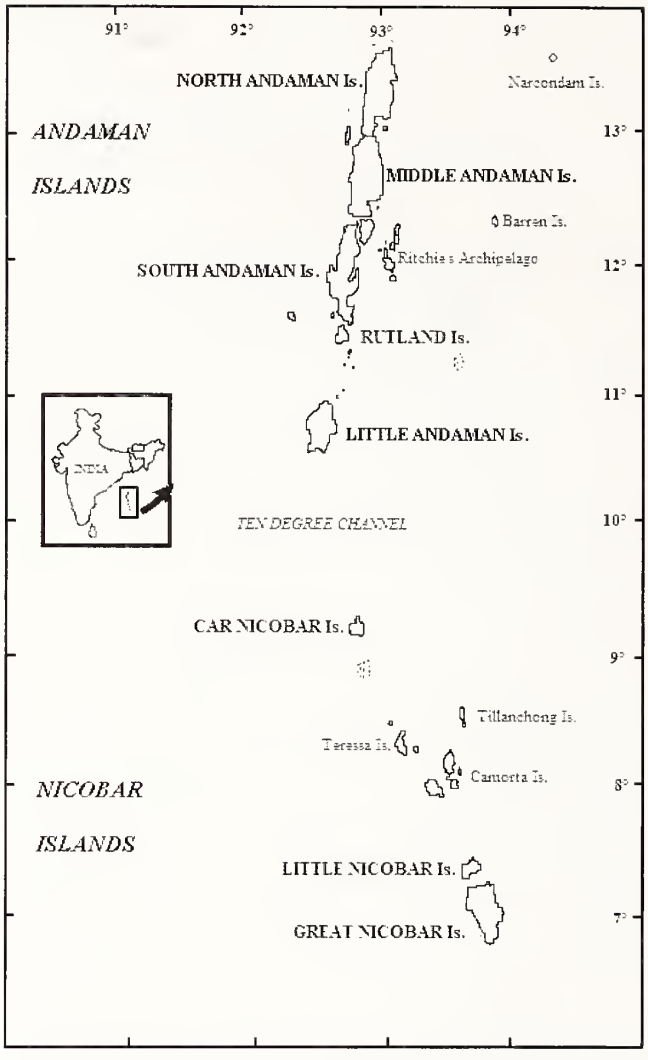


Fig. 1: Andaman and Nicobar Islands and its location in relation to India

Of the 33 species collected, 17 species (11 native) were freshwater fishes (Table 2) and 16 species were secondary freshwater or diadromous species. Some of the specimens that were collected during the survey were later identified as new species belonging to the genus *Sicyopterus* and *Schismatogobius*; genus *Schismatogobius* is the first report from this region. A Gobiid fish *Acentrogobius caninus* hitherto unknown to Andamans and is the first reporting from Indian inland waters.

## DISCUSSION

Biotas on islands have high levels of endemism and lower levels of diversity than those on mainland ecosystems (Osborne 2000). This is true in the case of freshwater fishes of Andaman Islands. Of the 33 species recorded by us, only 11 were native freshwater fishes including two new undescribed species. However, the endemism among

**Table 2**: Native, Exotic and Endemic Freshwater species and their Status

| Species | Native | Exotic | Endemic | Status |
|---|---|---|---|---|
| *Glossogobius giuris* | ✓ | - | - | Common |
| *Sicyopterus microcephalus* | ✓ | - | - | Very Common |
| *Sicyopterus* sp. | ✓ | - | ✓ | Common |
| *Awaous grammepomus* | ✓ | - | - | Rare |
| *Redigobius tambujon* | ✓ | - | - | Rare |
| *Schismatogobius* sp. | ✓ | - | ✓ | Very Rare |
| *Aplocheilus panchax* | ✓ | - | - | Very Common |
| *Channa orientalis* | ✓ | - | - | Common |
| *Microphis insularis* | ✓ | - | ✓ | Very Rare |
| *Stenogobius gymnopomus* | ✓ | - | - | Very Rare |
| *Acentorgobius caninus* | ✓ | - | - | Very Rare |
| *Parluciosoma daniconius* | - | ✓ | - | Common |
| *Heteropneustes fossilis* | - | ✓ | - | Common |
| *Clarias batrachus* | - | ✓ | - | Common |
| *Oreochromis mossambica* | - | ✓ | - | Common |
| *Anabas testudineus* | - | ✓ | - | Very Rare |
| *Channa striatus* | - | ✓ | - | Very Rare |

✓: recorded -: not recorded

freshwater fishes was moderately high with 27%. Three species *M. insularis*, *Schismatogobius* sp., and *Sicyopterus* sp. were endemic to the Andamans. About 21 species were reported by Herre (Herre 1939), including 7 freshwater and 14 estuarine species (Table 1). Five species of freshwater fish have been introduced deliberately or accidentally since the Herre's survey (Herre 1939).

The freshwater fish fauna of this region is somewhat impoverished due to low habitat diversity and its long isolation from continental Asia. There are possibilities that several undiscovered species living in the streams of these islands, particularly in tribal reserves and areas, are inaccessible. However, many of the native species of Andamans are threatened due to habitat loss (Petts 1984; Machado 1994; Glenn *et al.* 1996; Richter *et al.* 1997) and non-native species (Moyle and Leidy 1992; Ward *et al.* 2001). Therefore, it is important to protect freshwater streams in the Andaman Islands as they harbour a unique biodiversity and are the only sources of drinking water for human populations. The tribal reserves such as the Jarawa Reserve are now the only pocket of undisturbed forests and freshwater streams in the Andaman Islands should be kept free from external impact. It is imperative to formulate conservation strategies in order to protect the native fish species and their habitat of Andamans. Otherwise it is likely that several species may go extinct before they are ever discovered by science.

## ACKNOWLEDGEMENTS

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# THE LAND BIRDS OF SRIHARIKOTA ISLAND, SOUTHERN INDIA AND CONSERVATION ISSUES

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Surveys, censuses and mist-netting were carried out during 1976-1977, 1990-1994 and 2001-2008 to enumerate the land birds of Sriharikota Island, southern India. A total of 125 species of land birds were recorded comprising of 70 residents, 33 winter migrants and 12 seasonal migrants; the status of another 10 species is uncertain. An annotated checklist of these species is provided with special reference to their distribution in different habitat types. The White-rumped Vulture *Gyps bengalensis* has become locally extinct in the area. The conservation issues facing the Island, and especially the impact of plantations on the avifauna, are discussed and recommendations to mitigate these addressed.

**Key words**: Sriharikota, land birds, conservation issues, plantations, invasives

## INTRODUCTION

Sriharikota Island in the south-eastern coast of India is important from the biodiversity point of view as it has the last remaining, largest and best-preserved tracts of coastal Tropical Dry Evergreen Forest in India (Meher Homji 1974; Suryanarayana *et al.* 1989, 1998). The Island serves as the spaceport of India and has been under the administration of the Indian Space Research Organization (ISRO) since 1969. The faunal and floral diversity of the Island is fairly well-documented through a number of research projects over the years. The first investigation of the avifauna of Sriharikota Island were surveys of 10 and 15 days undertaken by the Bombay Natural History Society (BNHS) during 1976 and 1977 respectively (BNHS 1977). This was followed by an in-depth study by the BNHS from 1990 to 1994 (Samant and Rao 1996; Rao 1998). Subsequent to this, data was collected on the birds (and other wildlife) of the Island through two other projects (Manakadan and Sivakumar 2004a; Manakadan *et al.* 2008). A paper on the waterbirds of the wetlands of the region was published from the investigations in Sriharikota island and from studies carried out in the adjoining Pulicat lake, besides other wetlands and heronries in the mainland (Kannan *et al.* 2008). In this paper, we provide an annotated checklist of the land birds of Sriharikota Island and also discuss the conservation issues facing land birds.

## STUDY AREA

Sriharikota is a spindle-shaped island (181 sq. km) situated in Nellore and Tiruvallur districts of Andhra Pradesh and Tamil Nadu respectively. It is bounded on the east by the Bay of Bengal and on the north, south and west by the waters of Pulicat lake (Fig. 1). The Island comprises of low ridges of sand, marine and aeolian in origin, rising 4.5-6.0 m above msl and sloping from west to east. The water table is *c.* 2 to 5 m. Sriharikota has been connected by road to Sullurpet (18 km) on the mainland since 1970.

The rainfall is largely from the North-East Monsoon (October-December). Some rainfall is also received from the South-West Monsoon (June-September). The area is prone to cyclones, usually in the early part of May and October, during the onset of the two monsoons. The annual rainfall is *c.* 1,200 mm. December to February is the winter season, with temperatures being as low as 10 °C. March to September is the summer season with temperatures soaring over 40 °C. Relative humidity is lowest during May (18%), while the maximum (99%) is recorded during October.

Prior to the takeover of the Island by the Indian Space Research Organization (ISRO) between 1969 and 1972, there were around 20 villages on the Island with a total population of around 10,000 individuals. At present, besides the establishments of the Satish Dhawan Space Centre, SHAR (SDSC-SHAR), there are colonies established by ISRO for the former settlers and tribals of the Island, many of who work as labourers for ISRO. Access and movement on the Island is restricted. The SDSC-SHAR has a Conservation and Landscape Division for the conservation and management of the forests.

Sriharikota Island is important from the biodiversity point of view as it has the last remaining, largest and best-preserved tracts of coastal Tropical Dry Evergreen Forest

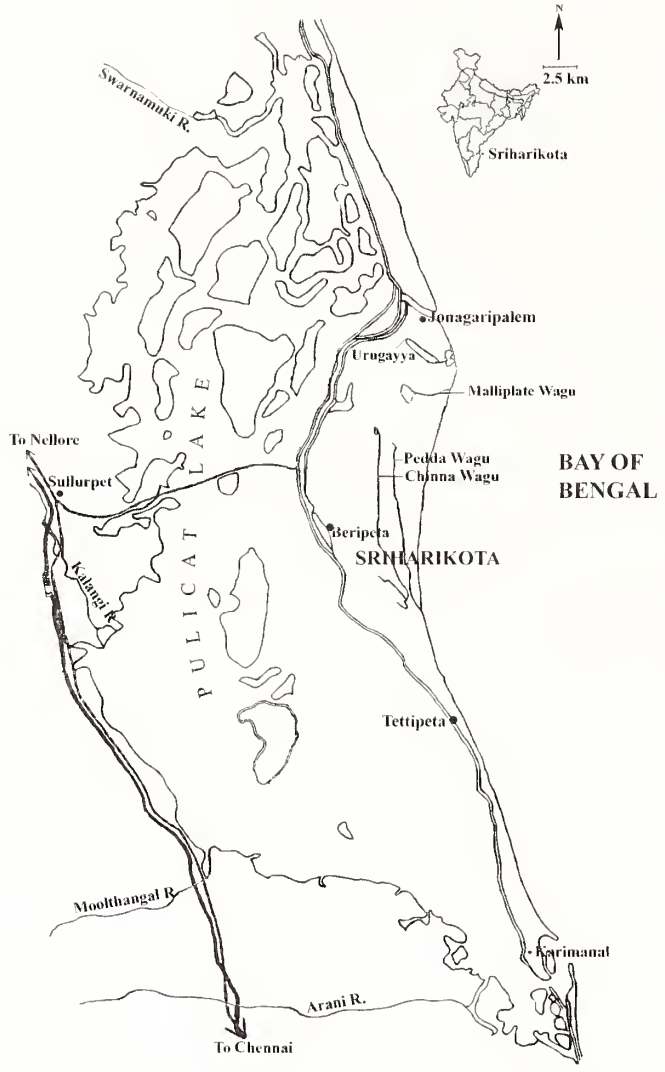


Fig. 1: Sriharikota Island and its adjoining areas

(TDEF) left in India. The forests had a long history of systematic clear-felling for fuel wood and timber starting with the British Era. Plantations of Eucalyptus (*Eucalyptus* spp.), Casuarina (*Casuarina equisetifolia*) and Cashew (*Anacardium occidentale*) had been raised over the years by the Forest Department and settlers, now covering approximately more than 20% of the landmass. After the establishment of the SDSC-SHAR in 1969, it's Conservation and Landscape Division (C & LD) continued raising these plantations for quick afforestation of bare or degraded areas, creation of shelter belts, and revenue and work generation for the tribals. *Acacia auriculiformis* was also introduced on a small scale in the 1970s by the C & LD. The invasive Chilean Mesquite *Prosopis chilensis* has proliferated in some areas, especially along the western edge of the Island that borders Pulicat lake, and towards the extreme southern parts of the Island. Another invasive species, Cane *Calamus rotang*, introduced during the late 19th century by the British, has colonised the edges of freshwater bodies and courses. Patches of abandoned coconut, tamarind, mango and palmyra (overgrown with native vegetation) planted by the former settlers are seen, especially in the southern tracts of the Island. Besides these, there are extensive grasslands with scattered shrubs or trees in the southern part of the island, and remnants of mangrove and salt marsh vegetation along the western edge of the Island.

The recorded fauna of this Island, other than birds, is represented by 27 mammal species, 12 species of amphibians, 34 species of reptiles, 44 species of fish and 51 species of butterflies. The mammals include the endangered Slender Loris *Loris lydekkerianus*, Jungle Cat *Felis chaus*, Rusty Spotted Cat *Prionailurus rubiginosus*, Bonnet Macaque *Macaca radiata*, Golden Jackal *Canis aureus*, Small Indian Civet *Viverricula indica* and the Indian Flying Fox *Pteropus giganteus*. The southern part of the Island has feral cattle (both buffaloes and cows) and a small population of feral horses (Anon 1908; Champion and Seth 1968; Meher Homji 1974; Reddy 1981, 1983; Agrawal *et al.* 1985; Suryanarayana *et al.* 1989, 1998; Manakadan and Sivakumar 2004a,b,c; Sivakumar and Manakadan 2004; Sivakumar *et al.* 2004; Manakadan *et al.* 2004).

## METHODS

This paper is based on findings of different workers who carried out field investigations on the land birds of Sriharikota from data obtained through surveys, systematic censuses, bird banding and specific studies (BNHS 1977; Samant and Rao 1996; Rao 1998; Manakadan and Sivakumar 2004a; Manakadan *et al.* 2008). The species account is largely based on the findings of two major projects: i) Samant and Rao (1996), Rao (1998) and ii) Manakadan and Sivakumar (2004a) as more intensive studies were carried out under these projects. Between these two studies, the first project was totally focused on birds with systematic census, bird banding and habitat studies undertaken. The second project was a part of an overall faunal inventory project of the Island and without bird banding, and thus was less intensive in data collection. The study by David *et al.* (2008) was also long-term and intensive, but was confined to frugivores. Thus, records of the other surveys/studies (BNHS 1977; David *et al.* 2008) and unpublished records (V. Santharam, Patrick David and B. Senthil Murugan) are discussed only if significant.

## RESULTS

The status, distribution and abundance of 125 species of land bird species of Sriharikota, with the English and scientific names following Rasmussen and Anderton (2005) are discussed below:

**Status**: R = Resident, with or without breeding records. WM = Winter Migrant: A species that breeds in the Palaearctic region/Himalayas during spring and 'winters' in the Indian subcontinent. SM = Seasonal Migrant: An 'Indian species' that occurs seasonally in the area. ? = Status Uncertain

**Abundance**: VC = Very Common: Sightings possible on almost all days in a year/season in suitable habitats. C = Common: Sightings of about once a week in a year/season in suitable habitats. O = Occasional: About one sighting fortnight/month in a year/season in suitable habitats. Ra = Rare: Less than 5 sightings per year or 3 sightings a season. VRa = Very Rare: Record based on only 1 or 2 sighting. VRa/O = Species recorded to be very rare during the earlier studies but was occasionally recorded during the later studies; and corresponding inferences for variations of these (e.g., O/VRa, C/VRa).

1. **Black Baza** ***Aviceda leuphotes*** (WM VRa)

The only records of the Black Baza were by Patrick David (unpublished data), who sighted two birds on November 12 and 14, 2007, and on February 06, 2008. The birds were sighted in the stretch between 'STEX' and 'PSLV', near the culvert over the Pedda Vagu. The second sighting was close to the first site and the third sighting was about 200 m from the first two sighting areas, all indicating that the sightings were of the same pair.

2. **Oriental Honey-Buzzard** ***Pernis ptilorhyncus*** (R C)

Rao (1998) found the Oriental Honey-Buzzard to be fairly common on the Island in well-wooded areas and particularly near eucalyptus plantations at Keepakam. Manakadan and Sivakumar (2004a) recorded the species only in TDEF and eucalyptus plantations.

3. **Black-winged Kite** ***Elanus caeruleus*** (R O)

Rao (1998) obtained only one sighting of the Black-winged Kite in an open grassy patch near Beripeta on August 20, 1990, but found it to be fairly common in agricultural fields on the mainland near Sullurpet. Manakadan and Sivakumar (2004a) recorded the species on a few occasions only in open scrub during summer. The species would probably be more common in the grassland areas in the southern part of the Island, which was rarely surveyed due to difficult logistics.

4. **Black Kite** ***Milvus migrans*** (R VRa)

The only record of the Black Kite in Sriharikota is of a bird in August 1990 near Kothachenu close to Pulicat lake (Rao 1998). This species, which inhabits towns and cities (Ali and Ripley 1987; Rasmussen and Anderton 2005), is also not common in the small towns on the mainland.

5. **White-rumped Vulture** ***Gyps bengalensis*** (R O/Extinct)

The first survey (BNHS 1977) discussed the White-rumped Vulture as 'soaring over many parts of the Island'. Rao (1998) recorded around 75-100 birds nesting on tall *Tamariudus indica* trees between November and March near Kodaledu. The largest flock size sighted by Manakadan and Sivakumar (2004a) consisted of 13 birds; all the other sightings consisted of 1-3 birds. Only one (unsuccessful) case of nesting was recorded during 2001. The birds disappeared towards the end of 2003 and have probably become locally extinct (see Discussion)

6. **Short-toed Eagle** ***Circaetus gallicus*** (R VRa)

The only record of the Short-toed Eagle was by Manakadan and Sivakumar (2004a), who sighted a pair in the western stretch of Fireline-12 in August 2003. Along with the characteristic '*piuuu-piuuu*' calls (Ali and Ripley 1987), the birds soared overhead for sufficient time to confirm identification. The status of the species is uncertain and the birds could be more common in the southern grassland areas of the Island (which was rarely visited) as it is partial to open habitats (Ali and Ripley 1987; Rasmussen and Anderton 2005).

7. **Crested Serpent-Eagle** ***Spilornis cheela*** (R Ra)

Rao (1998) recorded the Crested Serpent-Eagle only twice from eucalyptus plantations near Keepakam. Manakadan and Sivakumar (2004a) did not record the species during their study, nor was the species recorded during the first BNHS survey (BNHS 1977). However, Senthil Murugan (unpublished data) recorded it occasionally from 2004 to 2008.

8. **Pallid Harrier** ***Circus macrourus*** (WM Ra)

Rao (1998) obtained only two sightings of the Pallid Harrier: one bird on February 01, 1990, from Ravanappa Chatram and another on March 05, 1992, soaring over Keepakam. Santharam (unpublished data) saw a male on the Island in February 1990. Manakadan and Sivakumar (2004a) obtained only one sighting of a bird flying over Pulicat lake and heading towards Sriharikota in February 2003, and Patrick David (unpublished data) recorded the species once on the Island. The species could probably be more common in the grassland areas in the southern part of the Island, which was rarely surveyed due to difficult logistics.

9. **Shikra** ***Accipiter badius*** (R O)

The Shikra was occasionally sighted in TDEF forest and plantations by all the workers.

10. **Besra Sparrowhawk *Accipiter virgatus*** (WM VRa)

The only record of the Besra Sparrowhawk in Sriharikota is through a solitary individual ringed on February 27, 1991, from Keepakam. The species is known to winter in the Eastern Ghats (Ali and Ripley 1987; Rasmussen and Anderton 2005).

11. **White-eyed Buzzard *Butastur teesa*** (R O)

The White-eyed Buzzard was occasionally seen throughout the Island mostly in an open scrub habitat and at the edges of the forests and plantations.

12. **Common Kestrel *Falco tinnunculus*** (WM O)

The Common Kestrel was occasionally recorded in coastal sand dune areas, open scrub and the southern grassland areas during winter. The species would probably be more common in the open grassland areas in the southern part of the Island, which was rarely surveyed due to difficult logistics.

13. **Amur Falcon *Falco amurensis*** (WM VRa)

The Amur Falcon was recorded only on two occasions: a male in open scrub in November 2002 and a flock of five birds actively hunting dragonflies along casuarina plantations adjoining the seashore in May 2003 (Sivakumar and Manakadan 2006). Records of the Amur Falcon in Andhra Pradesh are rare, being known from only two old records, one from Nellore and another from Rajamundry (Ali and Ripley 1987).

14. **Peregrine Falcon *Falco peregrinus*** (WM VRa)

The Peregrine Falcon (race: *calidus*) was recorded only once flying low near coastal sand dunes in the Chandrasikuppam area on November 02, 1990.

15. **Grey Francolin *Francolinus pondicerianus*** (R C)

The Grey Francolin is a common species in Sriharikota, but restricted to open scrub habitat. The species is likely to be more common in the southern grassland-open scrub areas.

16. **Blue-breasted Quail *Coturnix chinensis*** (R/SM? VRa?)

The only record of the Blue-breasted Quail is by Manakadan and Sivakumar (2004a) who sighted a party of three birds near the STEX Gate in June 2003. Being secretive and small ground dwelling species, quails easily escape notice and may be more common than recorded. Rasmussen and Anderton (2005) describe the species status in the Indian region as 'largely resident, but movements require further study'.

17. **Red Spurfowl *Galloperdix spadicea*** (R VRa)

Rao (1998) obtained only one sighting of a pair of Red Spurfowl in scrub vegetation in the Ravanappa Chatram area. Manakadan and Sivakumar (2004a) recorded it only once (two birds) in TDEF forest.

18. **Grey Junglefowl *Gallus sonneratii*** (R VC)

The Grey Junglefowl is the commonest galliform species on the Island, occurring in almost all the forested areas of the Island. Manakadan and Sivakumar (2004a) located two nests in casuarina plantation, and Patrick David and Senthil Murugan (unpublished data) recorded a nest in TDEF forest.

19. **Yellow-legged Buttonquail *Turnix tanki*** (R VRa)

The only record of the Yellow-legged Buttonquail is a female ringed on March 27, 1990, from scrub forest in the north-east part of the Island. Buttonquails due to their small size and secretive nature easily escape notice and may be more common than recorded.

20. **Barred Buttonquail *Turnix suscitator*** (R VRa)

Rao (1998) recorded the Barred Buttonquail occasionally in open scrub forest having short grass patches. Manakadan and Sivakumar (2004a) did not record the species.

21. **Lesser Florican *Sypheotides indicus*** (SM? VRa)

The Lesser Florican was not recorded by BNHS workers, but Rao (1998) mentions of a possible sight record in 1988 by K.R. Seetharaman (former Head, Photography Division) from a grassy patch at Beripeta. There is a very old record of the existence of the threatened Lesser Florican from the Chennai area (Ali and Ripley 1987), *c.* 80 km south. The nearest known recent wintering site (with breeding recorded for one year) for the species is Rollapadu Wildlife Sanctuary, Kurnool district, Andhra Pradesh (Sankaran and Manakadan 1990; Manakadan and Rahmani 1999), *c.* 300 km north of Sriharikota. Suitable habitat for the Lesser Florican is available in the grassland areas to the south of the Island, which was rarely visited due to difficult logistics.

22. **Yellow-wattled Lapwing *Vanellus malabaricus*** (R Ra)

Rao (1998) recorded three Yellow-wattled Lapwings on August 21, 1990, at a grassy patch near Beripeta. The earlier BNHS survey (BNHS 1977) had recorded the species once and Manakadan and Sivakumar (2004a) recorded the species on two occasions. The species could probably be breeding in the undisturbed southern grassland areas.

23. **Indian Stone-Curlew *Burhinus indicus*** (R O)

The Indian Stone-Curlew was occasionally recorded in open scrub and grassy patches near Beripeta, and often

flushed under cashew bushes. Calls were also heard in the late evenings from Kothachenu and the surrounding scrub.

24. **Rock Pigeon *Columbia livia*** (R C)

The Rock Pigeon is a common species occurring mostly around buildings in the Island and near housing colonies, avoiding forested areas.

25. **Oriental Turtle-Dove *Streptopelia orientalis*** (R/SM O)

Rao (1998) occasionally recorded the Oriental Turtle-Dove from scrub areas in the Island during different times of the year, and more frequently near open scrub patches in Beripeta. Manakadan and Sivakumar (2004a) had a sighting of five birds around a waterhole in June 2002 and also recorded the species once each during census in TDEF and casuarina plantation. Patrick David and Senthil Murugan (unpublished data) obtained several sightings during 2007.

26. **Laughing Dove *Streptopelia senegalensis*** (R Ra)

Rao (1998) obtained a few sightings of the Laughing Dove mostly in scrub forest near Kodaledu and once near Beripeta in short grass. Manakadan and Sivakumar (2004a) recorded the species only once along the road adjoining the Buckingham Canal during March 2003. Patrick David and Senthil Murugan recorded the species regularly during their visits for study to the same area. The species is probably disappearing from areas inside the Island with the abandonment of villages and afforestation as it is partial to open scrub, village border environs and cultivation (Ali and Ripley 1987; Rasmussen and Anderton 2005).

27. **Spotted Dove *Streptopelia chinensis*** (R VC)

The Spotted Dove is the commonest dove on the Island, occurring in all localities including dense forest, open scrub and even plantations.

28. **Red Collared-Dove *Streptopelia tranquebarica*** (R/SM VRa)

Rao (1998) obtained a few sight records of the Red Collared-Dove during 1991, all from the Kodaledu scrub area. There are no other reports of the species on the Island.

29. **Orange-breasted Green-Pigeon *Treron bicinctus*** (SM/R?)

The Orange-breasted Green-Pigeon was not recorded during the first survey (BNHS 1977) and Rao (1998) obtained only two sightings from dense forest and scrub near Chandrasikuppam in November 1990. Manakadan and Sivakumar (2004a) recorded a small flock in January 2002 near Urugayya lake and again in March in the same area. David *et al.* (2008) recorded the species on a dozen occasions feeding in flocks on *Ficus* spp. fruits.

30. **Rose-ringed Parakeet *Psittacula krameri*** (R VC)

The Rose-ringed Parakeet is widely distributed over most areas of the Island, but is more common in the abandoned village forest areas, nesting in dead palm trunks.

31. **Plum-headed Parakeet *Psittacula cyanocephala*** (SM VRa)

Rao (1998) recorded the Plum-headed Parakeet in overhead flight and only from calls on a few occasions. It was recorded only once in overhead flight over casuarina plantation by Manakadan and Sivakumar (2004a). The only sight record was of a flock by Santharam (unpublished data) in April 1990. Judging from the few records, the species is probably a visitor from the Eastern Ghats.

32. **Greater Coucal *Centropus sinensis*** (R C)

The Greater Coucal is fairly common, occurring almost throughout the island, often seen foraging on ground near roads in a grassy patch. A nest was recorded on *Syzygium cumini* tree at a height of 7 m near Kodaledu.

33. **Blue-faced Malkoha *Phaenicophaens viridirostris*** (R C)

The Blue-faced Malkoha is fairly common in all areas of the Island and is partial to thorny scrub habitat and bushes up to 3-4 m.

34. **Chestnut-winged Cuckoo *Clamator coromandus*** (WM Ra)

Rao (1998) obtained only two sight records of the Chesntnut-winged Cuckoo in winter from dense thorny scrub near Kodaledu (December 1990) and Pedda Vagu (November 1991). Santharam (unpublished data) obtained a sighting during March 1990. Manakadan and Sivakumar (2004a) obtained only two sightings of single birds in January 2002 and February 2004 in TDEF forest.

35. **Jacobin Cuckoo *Clamator jacobinus*** (R/SM O/Ra)

Rao (1998) recorded the Jacobin Cuckoo occasionally in many areas, but especially in dense scrub patches. An albino was recorded in June 1991. However, Manakadan and Sivakumar (2004a) rarely recorded the species. Patrick David and Senthil Murugan (unpublished data) recorded the species only once during their study.

36. **Asian Koel *Endynamys scolopaceus*** (R C)

The Asian Koel occurs in dense forests and particularly around large fruiting trees like *Ficus*, abundant in abandoned village forest.

37. **Grey-bellied Cuckoo *Cacomantis passerinus*** (SM Ra)

Rao (1998) described the status of the Grey-bellied Cuckoo as 'hardly seen but presence mainly noted through

ringed individuals in winter', most caught from dense scrub patches at Kodaledu and Ravanappa chatram. Santharam (unpublished data) recorded the species thrice between February and April 1990. A bird (dark phase) was recorded by Manakadan and Sivakumar (2004a) in shrub vegetation in January 2002 in the central part of the Island. Patrick David (unpublished data) recorded a solitary bird in the Mavalam Wagu area in May 2007. The species is 'resident' in the Eastern Ghats (Ali and Ripley 1987; Rasmussen and Anderton 2005).

38. **Fork-tailed Drongo-Cuckoo *Surniculus (lugubris) dicruroides*** (SM VRa)

The only record of the Fork-tailed Drongo-Cuckoo is by Senthil Murugan (unpublished data), who recorded a solitary bird on November 22, 2006, in open tall forest in the abandoned village forest south of Jonagipallam. The species is 'a resident' in the Eastern Ghats (Ali and Ripley 1987; Rasmussen and Anderton 2005).

39. **Common Hawk-Cuckoo *Hierococcyx varius*** (R O)

The Common Hawk-Cuckoo presence was mainly recorded through its calls, mostly in forest habitats, except casuarina plantations.

40. **Small Cuckoo *Cuculus poliocephalus*** (WM VRa)

Rao (1998) recorded the Small Cuckoo only once on May 10, 1990, from cashew plantations near sand dunes in the northern part of the Island presumably on return migration. Manakadan and Sivakumar (2004a) recorded a bird (in hepatic phase) in open scrub between PSLV I and II in April 2003.

41. **Common Barn-Owl *Tyto alba*** (R Ra)

Rao (1998) obtained only a few sightings of the Common Barn-Owl, mostly from abandoned village forest areas. Manakadan and Sivakumar (2004a) recorded it only once (in casuarina plantation).

42. **Indian Scops-Owl *Otus bakkamoena*** (R VRa)

The occurrence of the Indian Scops-Owl in Sriharikota is not fully established with two brief sightings in abandoned village forest areas (Rao 1998).

43. **Indian Eagle-Owl *Bubo bengalensis*** (R VRa)

The record of the Indian Eagle-Owl is based only on a call heard by Rao (1998) once from a palmyra grove near swampy fields at Peddarettamala in March 1990.

44. **Mottled Wood-Owl *Strix ocellata*** (R VRa)

The presence of the Mottled Wood-Owl is known only from a juvenile ringed from Peddarettamala in March 1990 (Rao 1998). Manakadan and Sivakumar (2004a) sighted a pair in the Kothachenu area, where the pair was resident.

45. **Spotted Owlet *Athene brama*** (R O)

The Spotted Owlet was occasionally recorded in open scrub forest and around human habitation.

46. **Indian Jungle Nightjar *Caprimulgus indicus*** (R C)

Manakadan and Sivakumar (2004a) recorded the calls of the Indian Jungle Nightjar frequently in TDEF and eucalyptus plantations during night surveys. The calls heard were *chuck chuck chuck*, sometimes ending with *wowo*, *wowo*, *wowo*, the call reported from Sri Lanka (Ali and Ripley 1987).

47. **Indian Little Nightjar *Caprimulgus asiaticus*** (R O)

Manakadan and Sivakumar (2004a) recorded the calls of the Indian Little Nightjar occasionally during visits to open scrub areas during night surveys.

48. **Savanna Nightjar *Caprimulgus affinis*** (WM VRa)

The record of the Savanna Nightjar is based only from a road kill in December 1990 near Kothachenu (Rao 1998).

49. **Little Swift *Apus affinis*** (R O)

The Little Swift was only recorded around residential colonies, but not in the forest areas.

50. **Asian Palm-Swift *Cypsiurus balasiensis*** (R VC)

The Asian Palm-Swift occurs throughout the island, and is more abundant in areas that have palmyra *Borassus flabellifer* palms.

51. **Little Green Bee-eater *Merops orientalis*** (R C)

The Little Green Bee-eater was mainly recorded in open scrub habitat throughout the Island, and is probably more common in the southern grassland areas.

52. **Blue-tailed Bee-eater *Merops philippinus*** (WM O)

The Blue-tailed Bee-eater, which arrives by October each year and departs by March, is more common in open areas at the edge of forests and plantations.

53. **Indian Roller *Coracias benghalensis*** (R C)

The Indian Roller frequents open scrub areas, particularly in the western side of the Island. It could also be more common in the southern grassland-open scrub areas.

54. **Common Hoopoe *Upupa epops*** (R O)

The Common Hoopoe was mostly recorded in open scrub areas and abandoned village forest.

55. **Coppersmith Barbet** ***Megalaima haemacephala*** (R O)

The Coppersmith Barbet is largely confined to the abandoned village forest, which has an abundance of *Ficus* trees. In the rest of the Island, it is found mainly where *Ficus* trees occur, and sometimes on fruiting trees of *Syzygium cumini*.

56. **Black-rumped Flameback** ***Dinopium benghalense*** (R O)

The Black-rumped Flameback was recorded mostly in well-wooded areas of the Island, including plantations.

57. **Indian Pitta** ***Pitta brachyura*** (SM C/Ra)

Rao (1998) found the Indian Pitta to be a fairly common winter visitor. He saw and heard its calls from many areas in the northern and central parts of the Island in dense scrub forest. Manakadan and Sivakumar (2004a) obtained only one record from the edge of a casuarina plantation bordering scrub.

58. **Jerdon's Bushlark** ***Mirafra affinis*** (R O)

Rao (1998) obtained only a few records of the Jerdon's Bushlark in open grass patches near Beripeta and Chengalapalem, with one ringed around Chengalapalem. Manakadan and Sivakumar (2004a) recorded it occasionally in open scrub and young cashew plantations with low ground cover.

59. **Ashy-crowned Finch-Lark** ***Eremopterix griseus*** (R O/C)

The Ashy-crowned Finch-Lark was only occasionally recorded in the central and northern open sandy areas of the Island, but was a common species in the southern grassland areas.

60. **Oriental Skylark** ***Alauda gulgula*** (R C/O?)

Rao (1998) found the Oriental Skylark to be common in open grass patches as well as around dried waterbodies of Chengalapalem, Pedda Vagu and some other areas. Manakadan and Sivakumar (2004a) recorded the species only once in the dried-up backwaters of Pulicat lake near Beripeta. The species could probably be more common in the southern grassland areas of the Island, which was rarely visited due to difficult logistics.

61. **Barn Swallow** ***Hirundo rustica*** (WM O)

The Barn Swallow arrives by mid-August and departs by March. Large numbers were seen on the Sriharikota-Sullurpet road in November by Rao (1998) and by Manakadan and Sivakumar (2004a) along with the Red-rumped Swallow *Hirundo daurica*.

62. **Red-rumped Swallow** ***Hirundo daurica*** (WM VRa)

The only records of the Red-rumped Swallow in the Island are by Santharam (unpublished data), who sighted a few birds in flight during February and April 1990. However, huge flocks were seen perching on wires along the Sriharikota-Sullurpet road during winter as discussed under Barn Swallow.

63. **Wire-tailed Swallow** ***Hirundo smithii*** (R/SM VRa)

The Wire-tailed Swallow was only recorded by Rao (1998), who obtained a few sightings from Kothachenu of small flocks of up to eight birds perched on telegraph wires.

64. **Forest Wagtail** ***Motacilla indicus*** (WM O)

The Forest Wagtail was regularly sighted from TDEF forest and *Prosopis chilensis* forest and also ringed from Keepakam during winter. Some sightings were in late April and the first week of May.

65. **Paddyfield Pipit** ***Anthus rufulus*** (R C)

The Paddyfield Pipit occurs mainly on the western side of the island near open scrub and grassy patches at Chengalapalem and it is common in the southern grassland areas.

66. **Large Cuckooshrike** ***Coracina macei*** (SM VRa)

Rao (1998) obtained a few sightings of the Large Cuckooshrike from tall mixed forest dominated by palms near Peddarettamala in November 1990. Manakadan and Sivakumar (2004a) sighted only one bird in eucalyptus plantation in February 2003 during their study. Patrick David and Senthil Murugan did not record the species.

67. **Black-headed Cuckooshrike** ***Coracina melanoptera*** (WM O)

The Black-headed Cuckooshrike was occasionally recorded from the central forest areas of the Island along the Pedda and Chinna vagus, Palliveedhi and Sabari colony (Rao 1998; Manakadan and Sivakumar 2004a).

68. **Ashy Minivet** ***Pericrocotus divaricatus*** (WM VRa)

Rao (1998) recorded two birds once from tall mixed forest at Peddarettamala on February 27, 1991. Santharam (unpublished data) obtained call and sight (a pair) records on three occasions during February 1990. Manakadan and Sivakumar (2004a) obtained only one record of six birds along the Pedda Vagu area on the Zero Point – PSLV road during February 2003. The species has been reported from Chennai (Santharam 1990), *c.* 80 km south of Srihaikota. The Ashy Minivet which breeds in NE Asia and winters in SE Asia is a 'winter straggler' to the Indian region (Ali and Ripley 1987;

Rasmussen and Anderton 2005). The occurrence of the Ashy Minivet in Sriharikota and Chennai (=Madras) repeatedly (Santharam 1990) suggests that it is perhaps a regular but scarce winter visitor to the east coast of India.

69. **Small Minivet *Pericrocotus cinnamomeus*** (V VRa)

The only record of the Small Minivet in Sriharikota is by Patrick David (unpublished data) who recorded a solitary bird hunting for insects in dense forest at Keepakam on June 06, 2006.

70. **Common Woodshrike *Tephrodornis pondicerianus*** (R C)

The Common Woodshrike is a fairly widespread species, but rather rare in TDEF forest. It prefers thorny scrub patches and eucalyptus plantations, and in TDEF where eucalyptus trees were present.

71. **Asian Paradise Flycatcher *Terpsiphone paradisi*** (SM O)

The Asian Paradise Flycatcher is occasionally seen in Sriharikota in a variety of habitats, including dense forest groves. It occurs throughout winter and occasionally in summer.

72. **Black-naped Blue Monarch *Hypothymis azurea*** (SM Ra)

There are only a few records of the Black-naped Blue Monarch in Sriharikota with a bird ringed on March 20, 1990, at Beripeta. Manakadan and Sivakumar (2004a) and Patrick David (unpublished data) recorded the species only once during their studies.

73. **Red-whiskered Bulbul *Pycnonotus jocosus*** (R VC)

The Red-whiskered Bulbul is very common throughout the Island. In winter, large flocks congregate around eucalyptus blooms for nectar.

74. **Red-vented Bulbul *Pycnonotus cafer*** (R C)

The Red-vented Bulbul is less common than the other two bulbul species and is more partial to open scrub habitat.

75. **White-browed Bulbul *Pycnonotus luteolus*** (R VC)

The White-browed Bulbul is a very common species, more frequently heard than seen in dense scrub patches.

76. **Common Iora *Aegithina tiphia*** (R VC)

The Common Iora is a very common species occurring all over the Island, but was more frequently recorded in dense scrub and TDEF forest. It breeds from March till August, during which males were seen in full breeding plumage.

77. **Brown Shrike *Lanius cristatus*** (WM C)

The Brown Shrike is a common winter visitor and was recorded throughout the Island with the races *cristatus* and *lucionensis* recorded; the latter less common. The race *lucionensis* was first ringed in April 1990 (Mohapatra and Santharam 1992) near the SDSC-SHAR temple area and subsequently three more were ringed from the Kodaledu area (Rao 1998). The race *cristatus* arrives by mid-September and departs by mid-May. The race *lucionensis* is known to winter mainly in the Andaman Islands, but in recent years, they have been sighted increasingly in peninsular India (Mohapatra and Santharam 1992).

78. **Bay-backed Shrike *Lanius vittatus*** (WM Ra)

The Bay-backed Shrike was mostly recorded in the southern part of the Island having open scrub and sandy areas.

79. **Long-tailed Shrike *Lanius schach*** (WM Ra)

Rao (1998) recorded the Long-tailed Shrike infrequently with a few sightings from scrub habitat near the hospital and Mavalam Vagu areas. Manakadan and Sivakumar (2004a) did not record the species during their study.

80. **Orange-headed Thrush *Zoothera citrina*** (WM Ra)

The Orange-headed Thrush is an uncommon winter visitor, with both the races recorded. It prefers heavy undergrowth in TDEF forest.

81. **Asian Brown Flycatcher *Muscicapa daurica*** (WM O)

The Asian Brown Flycatcher is a widespread winter visitor though not common. Rao (1998) recorded individuals occasionally in the Kodaledu, Peddarettamala, Kothachenu areas and in the TDEF forest patches and ringed five birds between 1990-1992. Manakadan and Sivakumar (2004a) recorded the species in March 2003 in eucalyptus plantations and Patrick David and Senthil (unpublished data) recorded it during winter in many areas.

82. **Brown-breasted Flycatcher *Muscicapa muttui*** (WM VRa)

The presence of the Brown-breasted Flycatcher is known only from two individuals ringed in March 1991 from the Kothachenu area, possibly on return migration.

83. **Red-breasted Flycatcher *Ficedula parva*** (WM VRa)

The presence of the Red-breasted Flycatcher (race: *albicilla*) are known from a solitary female ringed on March 12, 1991, in dense *Prosopis chilensis* scrub at Keepakam and sightings of solitary birds by Santharam (unpublished data) and Manakadan and Sivakumar (2004a) during January 1990 and March 2003 respectively.

84. **Blue-throated Flycatcher** ***Cyornis rubeculoides*** (WM C)

The Blue-throated Flycatcher winters throughout the Island from mid-October to early April. The species was seen often in TDEF forest undergrowth, as well as in scrub habitat.

85. **Black Redstart** ***Phoenicurus ochruros*** (WM VRa)

Rao (1998) sighted the Black Redstart on a few occasions in scrub areas near Kodaledu and Kothachenu during winter. A female ringed was on February 10, 1992. The species was not recorded during the subsequent studies.

86. **Indian Blue Robin** ***Luscinia brunnea*** (WM VRa)

The Indian Blue Robin is known only through two birds ringed from dense scrub at Keepakam (April 03, 1990) and Beripeta (December 30, 1991), and is possibly a passage migrant.

87. **Oriental Magpie-Robin** ***Copsychus saularis*** (R C)

The Oriental Magpie-Robin is a common species in Sriharikota, occurring in scrub as well as TDEF forest.

88. **White-rumped Shama** ***Copsychus malabaricus*** (R C)

The White-rumped Shama occurs throughout the Island, but only where there is dense forest cover or dense patches.

89. **Indian Black Robin** ***Saxicoloides fulicatus*** (R Ra)

The Indian Black Robin is not a common species in Sriharikota, recorded only occasionally in scrub areas at Kodaledu, Kothachenu, Peddarettamala and Mavalam Vagu, all of which were former village areas.

90. **Yellow-billed Babbler** ***Turdoides affinis*** (R C)

The Yellow-billed Babbler is common in the Island and recorded occasionally in gardens in residential areas. The species is brood parasitized by the Jacobin Cuckoo.

91. **Yellow-eyed Babbler** ***Chrysomma sinense*** (SM? VRa)

The only record of the Yellow-eyed Babbler in Sriharikota is by Santharam (unpublished data), who heard its call during February 1990 and sighted a bird in March 1990 near the STEX area.

92. **Zitting Cisticola** ***Cisticola juncidis*** (R O)

The Zitting Cisticola is mostly seen in the north-east areas in open scrub and grass patches. It could probably be more common in the southern grassland areas.

93. **Grey-breasted Prinia** ***Prinia hodgsonii*** (R Ra)

Rao (1998) recorded the Grey-breasted Prinia on a few occasions from short grass and scrub near Kodaledu and towards the coast and did not see it elsewhere in the Island. The species could probably be more common in the southern grassland areas.

94. **Plain Prinia** ***Prinia inornata*** (R Ra)

The Plain Prinia was recorded in areas of dense grass near Kodaledu and in open scrub patches near Ravanappa Chatram by Rao (1998). The species could probably be more common in the southern grassland areas.

95. **Common Tailorbird** ***Orthotomus sutorius*** (R VC)

The Common Tailorbird is a very common species, occurring in most areas of the Island.

96. **Thick-billed Warbler** ***Acrocephalus aedon*** (WM VRa)

Rao (1998) records two Thick-billed Warblers from Kodaledu in December 1989 and January 1992. Santharam (unpublished data) and Manakadan and Sivakumar (2004a) recorded solitary birds during March 1990 and February 2002 respectively.

97. **Blyth's Reed-Warbler** ***Acrocephalus dumetorum*** (WM C)

The Blyth's Reed-Warbler was frequently recorded during winter over a variety of habitat types and particularly in TDEF. It arrives soon after the onset of the North-east monsoon and departs by the end of April. The site fidelity was recorded in the species with banded birds returning to the same site during subsequent winters.

98. **Indian Reed-Warbler** ***Acrocephalus (stentoreus) brunnescens*** (WM VRa)

The record of the Indian Reed-Warbler is known from two birds ringed in Chengalapalem during January 1990. The species could be more common in the reed beds around Katangayya Lake and the upper reaches of the Mavalam or Malliplate Vagu.

99. **Greenish Warbler** ***Phylloscopus trochiloides*** (WM C/ VRa)

Rao (1998) found the Greenish Warbler to be a widespread winter visitor in areas with good tree cover with records from late September to April. Birds were recorded to occupy the canopy of *Syzygium cumini* throughout winter and were also recorded in casuarina plantations. Manakadan and Sivakumar (2004a) did not record the species, but Senthil Murugan obtained frequent sightings during winter.

100. **Large-billed Leaf-Warbler** ***Phylloscopus magnirostris*** (WM Ra)

The Large-billed Leaf-Warbler was rarely recorded.

Two individuals ringed at Kodaledu (April 07, 1990) and Beripeta (April 30, 1991). Two birds were recorded on May 15, 1991, in *Albizzia amara* forest near Beripeta. Manakadan and Sivakumar (2004a) recorded two birds in the PHC-II residential areas in January 2002.

101. **Lesser Whitethroat *Sylvia curruca*** (WM Ra/C)

Rao (1998) found the Lesser Whitethroat to be relatively uncommon in Sriharikota with a very few sight records and only ten individuals were ringed in three years mostly from dense scrub patches in Keepakam, Kodaledu, and Chengalapalem. However, Manakadan and Sivakumar (2004a) recorded the species frequently during census in winter, and the species was also recorded by Patrick David and Senthil Murugan

102. **Pale-billed Flowerpecker *Dicaeum erythrorhynchos*** (R VC)

The Pale-billed Flowerpecker has a widespread distribution in the Island. It is especially abundant in old plantations of casuarina due to the abundance of its food plant *Dendrophthoe falcata* (=*Loranthus longiflorus*) growing as a stem parasite on casuarina.

103. **Purple-rumped Sunbird *Leptocoma zeylonica*** (R VC)

The Purple-rumped Sunbird is the most common species of sunbird on the Island, occurring over a variety of habitats.

104. **Purple Sunbird *Cinnyris asiaticus*** (R C)

The Purple Sunbird was recorded in most parts of the Island, occurring in a variety of habitats. Patrick David (unpublished data) found it to be the least common among the three sunbirds species of the Island.

105. **Loten's Sunbird *Cinnyris lotenius*** (R O)

The Loten's Sunbird is widespread but is not as common as the other two sunbirds with a restricted presence on the Island (Rao 1998; Manakadan and Sivakumar 2004a).

106. **Indian Silverbill *Euodice malabarica*** (R VRa)

The Indian Silverbill was recorded during the first survey (BNHS 1977) at Beripeta near Buckingham canal, but not by Rao (1998). Manakadan and Sivakumar (2004a) obtained only one sighting of two birds on a casuarina tree in scrub forest near Urugayya lake in April 2004. Munias could possibly be more common in the southern grassland areas of the Island.

107. **White-rumped Munia *Lonchura striata*** (R VRa)

The White-rumped Munia was recorded only during the first survey (BNHS 1977). Munias could possibly be more common in the southern grassland areas of the Island.

108. **Tricoloured Munia *Lonchura malacca*** (R VRa)

The only record of the Tricoloured Munia was by Rao (1998), sighting of a flock of six birds from the Chandrasikuppam near the coast in November 1990. Munias could possibly be more common in the southern grassland areas of the Island.

109. **House Sparrow *Passer domesticus*** (R VC/VRa)

The House Sparrow was recorded throughout the year near human habitation, but was rarely seen in the forest.

110. **Yellow-throated Sparrow *Petronia xanthocollis*** (R O)

The Yellow-throated Sparrow was occasionally recorded in scrub habitat at Beripeta and Kodaledu by Rao (1998) and in the Penubakkam area (Manakadan and Sivakumar 2004a). Besides occasional sightings, Patrick David and Senthil Murugan recorded a nest near the old launch pad.

111. **Baya Weaver *Ploceus philippinus*** (R Ra)

Rao (1998) recorded nests (with a male and three females) of the Baya Weaver hanging from a casuarina tree in dense evergreen scrub near Urugayya in September 1990. The species was also recorded by the first BNHS (1977) survey team in the Chinna Vagu, Beripeta and Mavalam Vagu areas. Manakadan and Sivakumar (2004a) did not record the species in the northern forested areas, but a few nests were once recorded during a survey of the southern grassland areas. Patrick David and Senthil Murugan (unpublished data) recorded them nesting in the Penubakkam area.

112. **Brahminy Starling *Temenuchus pagodarum*** (SM Ra)

Rao (1998) found the Brahminy Starling to be uncommon with 2-3 individuals noted occasionally from Mavalam Vagu, Beripeta and Kodaledu areas. A few sightings were also obtained in the Beripeta near cashew plantations. Manakadan and Sivakumar (2004a) sighted 10 birds in February 2002 near the PHC-I residential area and Patrick David and Senthil Murugan (unpublished data) recorded the species twice (Penubakkam and Urugayya areas).

113. **Rosy Starling *Sturnus roseus*** (WM VRa/O)

The Rosy Starling was not recorded during the first (BNHS 1977) and second surveys (Rao 1998). Manakadan and Sivakumar (2004a) first recorded it as large flocks feeding on the fruits of *Phoenix farinifera* in the southern grassland areas in March 2002. A few small flocks were occasionally sighted subsequently, including in residential areas. Large flocks roosting in mango trees in the residential areas during

December 2004. Patrick David and Senthil Murugan (unpublished data) obtained only one sighting: a flock in the southern area close to Karimanal.

114. **Common Starling** ***Sturnus vulgaris*** (WM VRa)

Rao (1998) obtained two possible sightings of the Common Starling in overhead flight near Peddarettamala and Kodaledu areas in flocks of 50 and 14 birds on February 17, 1992, and February 26, 1992, respectively. The record of the Common Starling in Sriharikota is one of the southernmost records for the distribution of species in India.

115. **Common Myna** ***Acridotheres tristis*** (R VC)

The Common Myna is one of the commonest land birds in Sriharikota, and was recorded in all the habitat types except casuarina and eucalyptus plantations.

116. **Indian Golden Oriole** ***Oriolus kundoo*** (SM O)

The Indian Golden Oriole is a winter visitor to the Island and occasionally seen from areas with good tree cover, and especially in abandoned village forest and residential areas. *Note*: We did not make attempts to confirm if the birds sighted were actually the Indian Golden Oriole or the very similar European Golden Oriole *O. oriolus*, as the two species were treated as conspecific till recently.

117. **Black Drongo** ***Dicrurus macrocercus*** (R C)

The Black Drongo is a common species in Sriharikota, occurring mostly in the TDEF forest as well as open scrub areas. The species breeds in Sriharikota.

118. **Ashy Drongo** ***Dicrurus leucophaeus*** (SM Ra)

Rao (1998) obtained a few sight records of the Ashy Drongo from the Beripeta area in winter with banding records of one bird each in Keepakam (March 12, 1991) and Beripeta (January 07, 1992). Manakadan and Sivakumar (2004a) recorded the species once at Kothachenu in January 2002.

119. **White-bellied Drongo** ***Dicrurus caerulescens*** (SM VRa/O)

Rao (1998) recorded the White-bellied Drongo only on a few rare occasions in dense thorny scrub and areas with tree cover at Kodaledu during December 1990. Manakadan and Sivakumar (2004a) did not record the species, but Patrick David and Senthil Murugan (unpublished data) recorded it on a number of occasions during winter, mainly feeding on nectar in eucalyptus plantations.

120. **Bronzed Drongo** ***Dicrurus aeneus*** (SM VRa)

The only record of the Bronzed Drongo in Sriharikota is by Patrick David (unpublished data), who recorded a bird in open tall forest south of Jonagipallem on May 11, 2007.

121. **Hair-crested Drongo** ***Dicrurus hottentottus*** (SM VRa)

The first record of the Hair-crested Drongo in Sriharikota was by Manakadan and Sivakumar (2004a) and Sivakumar and Manakadan (2003) who sighted two birds at the edge of an eucalyptus plantation bordering the Pedda Vagu stream near Picheruvu Gunta during June 2002. Patrick David (unpublished data) recorded two birds in the same area during his study. The distribution of the Hair-crested Drongo is the Himalayan foothills, NE India and downwards to the Eastern and Western Ghats (Ali and Ripley 1987) However, there have been stray records outside these areas, i.e., Kutch (Himmatsinhji 1997), Hyderabad (Pittie 1997) and Point Calimere (Natarajan and Balasubramaniam 1990).

122. **Ashy Woodswallow** ***Artamus fuscus*** (R C/O)

Rao (1998) found the Ashy Woodswallow to be fairly common occurring in tall mixed forest dominated by palms. Manakadan and Sivakumar (2004a) recorded them occasionally around Urugayya lake, Malliplate Vagu and the Beripeta area.

123. **Rufous Treepie** ***Dendrocitta vagabunda*** (R VRa/O)

The Rufous Treepie species has not been recorded in the central and northern areas of the Island.

Its first record was of a pair near Karimanal in the southern part of the Island in March 2002 (Manakadan and Sivakumar 2004a). After that, the species was occasionally recorded during visits to the southern part of the Island (south of Tettipeta), where it probably breeds. Senthil Murugan heard its call in the southern part of the Island after Jonagipallem.

124. **House Crow** ***Corvus splendens*** (R VC)

The House Crow was recorded mostly frequenting housing and office areas, avoiding dense forest.

125. **Eastern Jungle Crow** ***Corvus (macrorhynchos) levaillantii*** (R C)

The Eastern Jungle Crow is a common species in all areas including human habitation, but also inhabits forests and scrub areas of the Island unlike the House Crow.

(Other than those listed above, the other bird species that are not typical waterbirds but are wetland dependent, namely fish-eagles, marsh-harrier, fish-owls, pratincoles, kingfishers and wagtails) also occur on the Island. For accounts on the species, see Kannan *et al.* (2008).

## DISCUSSION

### Profile of the land birds

The land birds recorded in Sriharikota Island comprise of (i) 70 resident species with or without breeding records (ii) 33 species of winter migrants from the Palaearctic region/ Himalayas, (iii) 12 species of seasonal migrants coming either from the Eastern Ghats or other regions of India, and (iv) 10 species are of uncertain status due to paucity of records.

Even for some of the species classed as residents (e.g., Black-winged Kite, Short-toed Snake-Eagle, Oriental Turtle-Dove, Asian Koel, Wire-tailed Swallow), their status is uncertain due to few records or as these species were absent/ scarce during certain periods/seasons in the Island, indicating that they are either visitors from surrounding areas or are species that periodically move out of the Island unlike the 'true residents', such as the three species of bulbuls and sunbirds among others, which are seen throughout the year. Similarly, the paucity of records for some of the winter migrants (e.g., Black Baza, Besra Sparrowhawk, Amur Falcon, Common Starling) and seasonal migrants (e.g., Blue-breasted Quail, Yellow-eyed Babbler, Fork-tailed Drongo-Cuckoo, Bronzed Drongo and Hair-crested Drongo) raises the question whether these species visit the Island only during certain years due to adverse habitat conditions in their usual wintering range (for migrants) and distributional range (in case of seasonal migrants) or these are cases of 'vagrants'. The occurrence of Eastern Ghats hill birds (e.g., Fork-tailed Drongo-Cuckoo, Bronzed Drongo, Hair-crested Drongo) or those that winter in the Ghats (e.g., Besra Sparrowhawk) in this coastal strip is not surprising as the hill ranges run parallel to the Island with some of the hills being only 50 km from Sriharikota. The Eastern Ghats and the forest of Sriharikota share a good number of plant species with Sriharikota except endemic species of tropical dry evergreen forest (Meher Homji 1974). The relatively undisturbed (no woodcutting and movement of people) forest in Sriharikota probably, attract these bird species to the Island.

As for the abundance of bird species, underestimates can be expected for small, secretive birds and especially ground birds, such as quails and buttonquails, and also nocturnal species such as owls and nightjars. Another bias is that the southern part of the Island was much less surveyed due to the distance and difficult logistics. This area is a mixture of grasslands, open scrub and sand dune vegetation, ideal habitats for birds that inhabit or prefer grasslands and open habitats, such as harriers, larks and pipits. Hence, such species could be more abundant in these areas, and thus in Sriharikota, than recorded.

### Changes in the avifauna

Some changes in the avifauna are apparent while comparing the observations of different workers, though these are not strictly comparable as the sampling effort and time varied considerably due to the nature of the studies. One of the most dramatic changes is the decline of the White-rumped Vulture with the birds now probably extinct in Sriharikota and the surrounding areas (see species account). In India, the *Gyps* vultures, have been facing a severe population decline in the past decade with more than 95% decline in some areas due to drug diclofenac given to cattle, on whose carcasses the vultures feed (Prakash *et al.* 2003).

Granivorous species such as munias and bayas also are likely to have undergone decline. Nests of the Baya Weaver were recorded in the Chinna Vagu, Beripeta and Malliplate Vagu by the first survey team (BNHS 1977) and on casuarina trees near Urugayya during the second study (Rao 1998). Manakadan and Sivakumar (2004a) did not record the species in the northern forested areas, but a few nests were once recorded during a survey in the southern grassland areas. The Baya, besides munias, have probably disappeared from the northern parts of the Island after cultivation stopped with the removal of the villages, as these species are primarily seedeaters and thrive around grassland and agricultural areas (Ali and Ripley 1987). It also appears that there has been a decline in species that are partial to open habitat (open scrub, grassy patches and around human habitation) in the central areas of Sriharikota due to the increase in forest cover, either naturally or aided by afforestation schemes. These species include the Red-vented Bulbul, Laughing Dove, munias and Baya Weaver. In the central densely forested area, these species were recorded largely in open scrub patches.

### Impact of plantations

Two studies carried out in Sriharikota (Rao 1998; Manakadan and Sivakumar 2004a) revealed that overall plantations result in pauperisation of bird fauna, which was further confirmed in a study on frugivorous birds (David *et al.* 1998). Among the plantations, species richness and abundance of birds was found to be higher in eucalyptus compared to casuarinas and cashew plantations. This was because eucalyptus plantations in Sriharikota have a good mix of the native vegetation, especially as an under-storey. In casuarina, the spacing between trees is narrow and the dense litter formation permits only sparse undergrowth. The most destructive plantation species to the native vegetation (and birdlife) is cashew with almost no other plant species surviving under mature cashew plantations due to its spreading nature.

Eucalyptus is attractive to nectar feeding birds like bulbuls, flowerpecker and sunbirds only during the flowering season. Even though nectar feeding bird densities (especially Pale-billed Flowerpecker) were also high in casuarina, this was due to the abundance of the parasitic plant *Dendrophthoe falcata* (=*Loranthus longiflorus*) on casuarina. *D. falcata* is a major food plant of the Pale-billed Flowerpecker, which also acts as a seed disperser for this parasite (Ali and Ripley 1987). *D. falcata* was also present in the other vegetation types, but was not as common as in casuarina plantations. Besides *D. falcata*, the presence of a fleshy-fruiting species of climbers on the canopies of casuarina such as *Olax scandens* also attracted bird species. Besides the Pale-billed Flowerpecker, the only other species recorded in good numbers in plantations was the Common Woodshrike, almost restricted to eucalyptus. Even the records obtained of the species in natural forest were in areas that had an isolated patch of eucalyptus trees. The Common Woodshrike is partial to secondary forest (Ali and Ripley 1987), which may explain its relative abundance in eucalyptus plantations. A number of other studies have also shown that plantations, especially single-species ones, are detrimental to bird species (Gandhi 1986; Evans 1992; Fogarty and Vilella 2003).

A positive factor of the plantations in Sriharikota is that silvicultural practices as undertaken in commercial plantations such as high density planting, dead tree and weed removal, and short-rotation harvesting (8-10 years) are not practiced, as the plantations are raised primarily for afforestation and shelter-belts. Hence, most of the existing plantations are more than 20 years old and with a good mix of native vegetation. This has resulted in less severity of environmental conditions that occur in commercial plantations due to single species domination.

## CONSERVATION ISSUES

Though relatively well protected, the forests of Sriharikota also face threats, some of which have impacts on land birds.

### Plantations

The trend in India is that formations lacking in timber species are as a rule considered useless and felled or replaced by plantations, little realising that these have rich diversity and are repositories of economic-medicinal plants and natural habitat for wildlife (Meher Homji 1997). As discussed earlier, Sriharikota too has a history of clearing of native vegetation to raise fast growing or commercially important species for afforestation, shelter-belts, stabilising sand dunes, and revenue and employment generation. Studies in Sriharikota have confirmed the deleterious impact of plantations on birds (David *et al.* 1998; Rao 1998; Manakadan and Sivakumar 2004a), besides mammals (Manakadan and Sivakumar 2004a), herpetofauna (Sivakumar and Manakadan 2004) and butterflies (Sivakumar *et al.* 2004). Fortunately, the earlier practice of clearing the native vegetation to raise plantations has stopped after BNHS representations to SDSC-SHAR and plantations are now raised in open scrub or sandy area. Another positive outcome has been the ban on raising new eucalyptus plantations.

### Invasives

Chilean Mesquite *Prosopis chilensis* and Cane *Calamus rotang* are major invasive plant species in Sriharikota. The Chilean Mesquite, an exotic from South America, has proliferated on its own in areas that faced clearing in the past and where the soils are saline (mostly in areas bordering Pulicat lake). Forestry experts need to be consulted on ways to eradicate this species as it has come up again in the same areas where they were eradicated earlier through uprooting and burning on a number of occasions. From our observations, species that can probably be planted after removal of Mesquite appear to be *Lannea coromandelica* and *Salvadora persica*, as both these species occur in saline soil areas. Another strategy could be to target *Prosopis* dominated areas for expansion of the spaceport. Cane, introduced during the British Era, has now spread and engulfed most of the freshwater streams and ponds, and their margins eliminating native vegetation. SDSC-SHAR has started large-scale commercial exploitation of cane in recent years and this may help check its spread. However, there is a need to directly deal with the problem in areas that have been totally engulfed with cane. Another invasive that is now seen in the residential and office compounds of Sriharikota is *Lantana camara*, which is a major problem in many forests tracts of India. Once established, it forms a dense shrub layer preventing other plants from surviving. Steps must be taken to weed out the species from the Island and not introduce it into residential areas, gardens and parks.

### Expansion of the spaceport

The developmental activities and expansion plans of the SDSC-SHAR have been making demands on the land. Large tracts of land were taken over by the spaceport for construction of a number of new buildings, facilities and for a new launch pad in recent years. Though acquisition of land for such purposes is unavoidable, measures could be taken up to lessen the impacts on the wildlife and their habitats such as (i) Acquiring land dominated by mesquite, eucalyptus and areas largely devoid of vegetation, (ii) Optimal use of

land for expansion plans and adopting landscape designing to retain as much of the native vegetation as possible around new facilities, and (iii) Demarcation of exclusive biodiversity conservation zones.

## CONCLUSION

With India's alarming biodiversity loss, especially in recent times, places like Sriharikota, with limited human intrusion, become significant for biodiversity conservation and could become more so in the future. It would not be wrong to assume that very little of the forest or wildlife of Sriharikota would have remained if ISRO had not taken over the Island. Sriharikota is very important from the biodiversity point of view as it has one of the last remaining, largest and best-preserved tract of the coastal Tropical Dry Evergreen Forest in India. Hence, we have recommended that the ISRO authorities at Sriharikota define the forest conservation and management policy in Sriharikota as: "All future efforts towards the conservation of the wilderness areas of Sriharikota should aim at maintaining the natural biodiversity and helping it revert back to its pristine nature."

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# ECHINODERMS OF NIZAMPATNAM BAY, EAST COAST OF INDIA

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The present study provides information about systematics and distribution of echinoderms for the first time along the Nizampatnam Bay, east coast of India. The study carried out over two consequent Post-monsoon seasons (October-November 2006, 2007) and two Pre-monsoon seasons (March-April 2007, 2008) spanning an area of 20 GPS fixed stations (15° 30' 000"-15° 47' 500" N; 80° 17' 000"-80° 45' 000" E) along the Nizampatnam Bay, east coast of India. Altogether 18 species were identified represented by 17 genera, 13 families, 8 orders and 3 classes. During the present study, the asteroid *Astropecten velitaris* has been added to the fauna of India, the asteroids – *Luidia hardwicki*, and *Echinaster purpureus*, *Goniodiscaster* sp., the ophiuroids – *Ophiocnemis marmorata*, and *Ophiothrix* sp. and the echinoids – *Salmaciella dussumieri*, *Salmacis virgulata* and *Clypeaster humilis* have been added as new species to Andhra Pradesh.

**Key words**: Echinoderms, Nizampatnam Bay, east coast of India

## INTRODUCTION

Echinoderms are exclusively marine organisms and are widely distributed in benthic habitats from the intertidal zone to the deep sea. Apart from the mention in the comprehensive accounts of R.I.M.S *Investigator* collections, there have been a few accounts, particularly of the echinoderms of Andhra Pradesh. Notable among these are of Ganapati and Rao (1962a, b), Radhakrishna and Ganapati (1968) and Vijayakumar *et al.* (1991). However, these are mainly directed towards ecological aspects with only cursory accounts or lists of fauna. Sastry (2007) prepared an annotated list of echinoderm species reported from the Indian coast with state-wise distribution. Based on the literature, it could be stated that there is no information on echinoderms from the Nizampatnam Bay, east coast of India. This is the first available data set on echinoderms from the Nizampatnam Bay, east coast of India. A detailed description and distribution are presented here.

## MATERIAL AND METHODS

The study was carried out over two consequent post-monsoon seasons (October-November 2006, 2007) and pre-monsoon seasons (March-April 2007, 2008) spanning an area of 20 GPS fixed stations (15° 30' 000"-15° 47' 500" N; 80° 17' 000"-80° 45' 000" E) along the Nizampatnam Bay, east coast of India (Table 1; Fig. 1). A naturalist's dredge made of a metal frame (30 cm x 45 cm), fitted with a nylon mesh (1 sq. cm) net and appropriately weighed, proved useful and worked quite satisfactorily up to 50 m while collecting benthos. Altogether, 100 dredge hauls were made. At each location, the dredge was operated for 10-15 minutes at 1.5 knots. Only live specimens were picked and the fauna narcotized and preserved in 5% formalin, later transferred to 70% alcohol and labelled for further work. Simultaneously, observations on environmental variables (sea temperature, dissolved oxygen, salinity, sediment texture-sand, silt, clay or organic matter) were made according to standard protocols (Holme and McIntyre 1984). Biological examination included taxonomic identification based on standard literature (Clark

**Table 1**: Station Locations

| Station No. | Depth (m) | Latitude | Longitude |
|---|---|---|---|
| 1 | 11 | 15°36′000″ N | 80°17′000″ E |
| 2 | 11 | 15°43′000″ N | 80°22′000″ E |
| 3 | 11 | 15°46′000″ N | 80°27′000″ E |
| 4 | 11 | 15°47′500″ N | 80°34′000″ E |
| 5 | 10 | 15°46′000″ N | 80°41′000″ E |
| 6 | 13 | 15°37′000″ N | 80°22′000″ E |
| 7 | 13 | 15°42′000″ N | 80°29′000″ E |
| 8 | 13 | 15°44′000″ N | 80°37′000″ E |
| 9 | 15 | 15°30′000″ N | 80°20′000″ E |
| 10 | 15 | 15°36′000″ N | 80°27′000″ E |
| 11 | 15 | 15°40′000″ N | 80°34′000″ E |
| 12 | 12 | 15°30′000″ N | 80°22′000″ E |
| 13 | 20 | 15°30′000″ N | 80°31′000″ E |
| 14 | 20 | 15°32′500″ N | 80°34′000″ E |
| 15 | 22 | 15°36′000″ N | 80°41′000″ E |
| 16 | 24 | 15°37′000″ N | 80°45′000″ E |
| 17 | 24 | 15°28′000″ N | 80°34′000″ E |
| 18 | 26 | 15°31′000″ N | 80°38′000″ E |
| 19 | 34 | 15°33′000″ N | 80°41′000″ E |
| 20 | 26 | 15°35′500″ N | 80°45′000″ E |

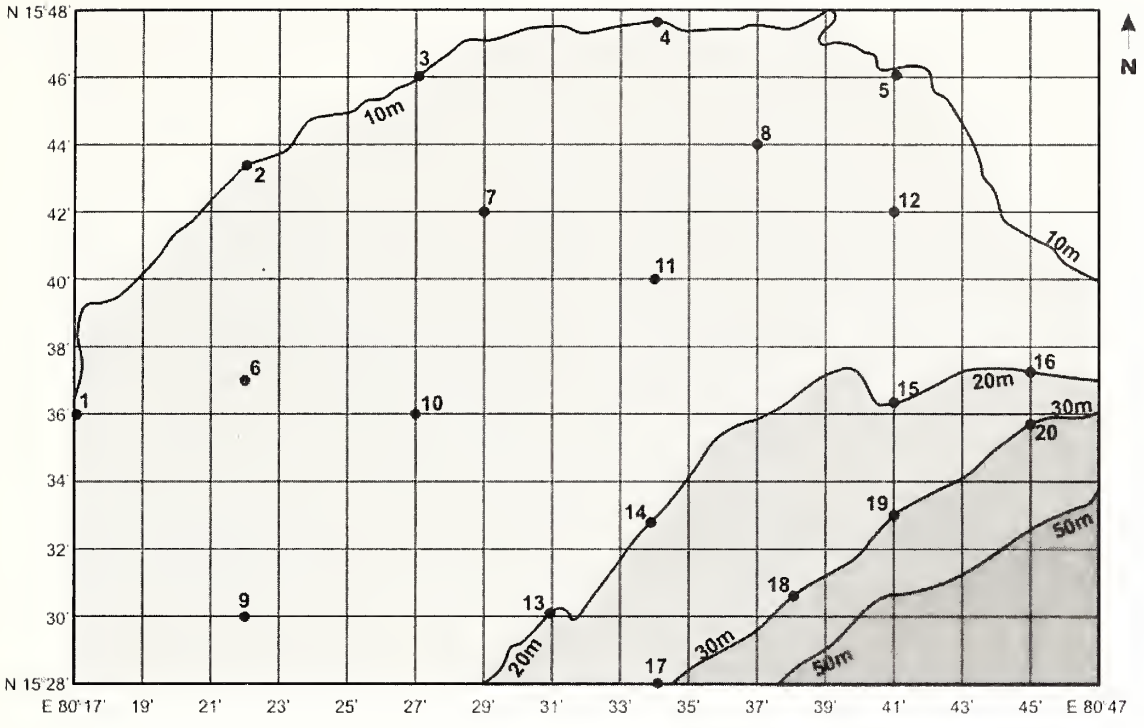


Fig. 1: Study Area

and Rowe 1971; Sastry 2007) and estimations of numerical abundance and biomass.

## RESULTS

Altogether 18 species belonging to 17 genera, 13 families, 8 orders and 3 classes have been identified and reported for the first time from the Nizampatnam Bay. Information on the environmental conditions and organic matter content is presented in Table 2.

In the Bay, the hydrographical conditions are characterised by salinity that varied between 24.8 PSU (st.6, November 07) and 36.81 PSU (st.3, March 07; st.18, March 08), the temperature ranged between 25.0 °C (st.9, March 07) and 34.1 °C (st.13, October 06) and the dissolved oxygen in the bottom waters ranged from 1.344 ml/l (st.9, October 06) to 5.824 ml/l (st.6, November 07). Sediment organic matter ranged between 0.09% (sts.9,12, October 06) and 2.54% (st.1, March 07). Table 3 contains a classified list of the echinoderm taxa and its distribution in the Nizampatnam Bay.

**Table 2**: Environmental variables of Nizampatnam Bay

| | |
|---|---|
| Temperature (°C) | 25.0-34.1 (29.39 ±1.51) |
| Salinity (PSU) | 24.8-36.81 (32.25 ±3.07) |
| DO (ml/l) | 1.344-5.824 (3.64 ±0.91) |
| Organic Matter | 0.09-2.54 (1.26 ±0.36) |

Note: Values presented range, mean ± S.D.

**Abbreviations**:

R - the major radius, from centre to arm tip; r - the minor radius, from centre to interradial edge; br - across the base of the arm; d.d - disc diameter; D - diameter; H - height

**Phylum**: Echinodermata
**Class**: Asteroidea
**Order**: Paxillosida

**Family**: Luidiidae

1. ***Luidia hardwicki*** (Gray, 1840)

1971. *Luidia hardwicki*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 44 (key), 30-31 (distribution).

2007. *Luidia hardwicki*: Sastry, D.R.K.: *Rec. zool. Surv. India, Occ. Paper* No. *271*: 24.

**Material**: Andhra Pradesh: Guntur district,

**Table 3**: Checklist and distribution of Echinoderms of Nizampatnam Bay

| Species | Stations | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| **Class** Asteroidea | | | | | | | | | | | | | | | | | | | | |
| **Order** Paxillosida | | | | | | | | | | | | | | | | | | | | |
| **Family** Luidiidae | | | | | | | | | | | | | | | | | | | | |
| *Luidia* (*Luidia*) *hardwicki** | + | - | - | - | - | - | - | - | + | - | - | - | - | - | + | - | + | + | + | - |
| **Family** Astropectinidae | | | | | | | | | | | | | | | | | | | | |
| *Astropecten velitaris*** | + | - | - | - | - | - | - | - | + | - | - | - | + | - | - | - | + | + | + | - |
| **Order** Valvatida | | | | | | | | | | | | | | | | | | | | |
| **Family** Oreasteridae | | | | | | | | | | | | | | | | | | | | |
| *Anthenea pentagonula* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + | - | - |
| *Goniodiscaster* sp.* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + | - | - |
| **Order** Spinulosida | | | | | | | | | | | | | | | | | | | | |
| **Family** Echinasteridae | | | | | | | | | | | | | | | | | | | | |
| *Echinaster purpureus** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + | - | - |
| **Class** Ophiuroidea | | | | | | | | | | | | | | | | | | | | |
| **Order** Ophiurida | | | | | | | | | | | | | | | | | | | | |
| **Family** Amphiuridae | | | | | | | | | | | | | | | | | | | | |
| *Amphioplus* (*Lymanella*) *depressus* | + | + | + | - | + | + | + | - | + | - | + | + | + | + | + | + | + | + | + | + |
| **Family** Ophiotrichidae | | | | | | | | | | | | | | | | | | | | |
| *Ophiocnemis marmorata** | + | + | + | - | + | + | + | - | + | - | + | + | + | - | - | + | + | + | + | + |
| *Ophiothrix* sp.* | - | - | - | - | - | - | - | - | + | - | - | - | + | - | - | + | + | - | - | - |
| **Class** Echinoidea | | | | | | | | | | | | | | | | | | | | |
| **Order** Diadematoida | | | | | | | | | | | | | | | | | | | | |
| **Family** Diadematidae | | | | | | | | | | | | | | | | | | | | |
| *Chaetodiadema granulatum* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + | - |
| **Order** Temnopleuroida | | | | | | | | | | | | | | | | | | | | |
| **Family** Temnopleuridae | | | | | | | | | | | | | | | | | | | | |
| *Salmaciella dussumieri** | - | - | - | - | - | - | - | - | + | - | - | - | - | + | - | - | + | + | + | - |
| *Salmacis virgulata** | - | - | - | - | - | - | - | - | + | - | - | - | - | - | - | - | + | + | + | - |
| *Temnopleurus toreumaticus* | + | - | + | + | + | - | - | + | + | - | - | + | - | - | + | - | - | + | + | - |
| **Order** Clypeasteroida | | | | | | | | | | | | | | | | | | | | |
| **Family** Clypeasteridae | | | | | | | | | | | | | | | | | | | | |
| *Clypeaster humilis** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + | - | - |
| *Clypeaster rarispinus* | + | + | - | - | - | - | - | + | + | - | + | - | - | + | + | - | + | + | + | - |
| **Family** Astriclypeidae | | | | | | | | | | | | | | | | | | | | |
| *Echinodiscus auritus* | - | - | - | - | - | - | - | - | + | - | - | - | - | - | - | - | + | + | - | - |
| **Order** Spatangoida | | | | | | | | | | | | | | | | | | | | |
| **Family** Brissidae | | | | | | | | | | | | | | | | | | | | |
| *Brissopsis luzonica* | - | - | - | - | - | - | - | - | - | - | + | + | - | + | + | - | + | + | + | - |
| **Family** Spatangidae | | | | | | | | | | | | | | | | | | | | |
| *Nacospatangus* (*Pseudomaretia*) *alta* | - | - | - | - | - | - | - | - | + | - | - | - | + | + | - | - | + | + | + | - |
| **Family** Loveniidae | | | | | | | | | | | | | | | | | | | | |
| *Lovenia elongata** | - | - | - | - | - | - | - | - | - | - | - | - | - | + | - | - | + | + | - | + |

\+ Present; - Absent

** New Report from India; * New Reports from Andhra Pradesh

Nizampatnam Bay. During October 2006, single specimen was collected from st.9; two specimens from st.15, of which one specimen has the longest arm (R/r = 45/8 mm) and the second has regenerating arms of 20-22 mm size; two specimens from st.17, larger specimen with complete arm (R = 75 mm), other arms are broken; five specimens from st.18 (four specimens R = 11-65 mm); five specimens from st.19 (two specimens R/r = 37/7 and 32/7mm). In March 2007, two specimens were collected from st.1, single specimen from st.18. In November 2007, twelve specimens were collected from st.17, two from st.18, eight from st.19.

**Remarks**: The specimens measure 12-75 mm in R and r = about 5 mm; some of the specimens have only one complete arm and the others are broken or regenerating small arms.

**Distribution**: INDIA: Maharashtra, Tamil Nadu and West Bengal. The specimens are newly recorded from Andhra Pradesh. ELSEWHERE: SE Arabia, Persian Gulf, Islands of Western Indian Ocean, Bay of Bengal, East Indies, South China Sea and North Australia.

**Family**: Astropectinidae

2. ***Astropecten velitaris*** von Martens, 1865

1865. *Astropecten velitaris*: von Marten

1971. *Astropecten velitaris*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 46 (key), 30-31 (distribution).

1989. *Astropecten velitaris*: Clark, A.M. *In*: Jangoux, M. & J.M. Lawrence (eds): Echinoderm Studies *3*: 47

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay, two specimens: R = 9 and 10 mm (st.18); two specimens R = 18 mm (st.19); one specimen (st.17), eight specimens (st.9) were collected in October 2006; single specimen (sts.1,9,18), two specimens (st.17) collected in March 2007; three specimens (st.9), single (st.13), four specimens (st.17) in November 2007, and single specimen (st.13, March 2008).

**Remarks**: The specimens measure 7-62 mm in R and R = 4.0-4.5 r.

**Distribution**: The species is new to India. ELSEWHERE: Sri Lanka, East Indies, South China Sea and North Australia.

**Order**: Valvatida

**Family**: Oreasteridae

3. ***Anthenea pentagonula*** Lamarck

1816. *Anthenea pentagonula* Lamarck, J.B.P.A. de: *Hist. nat. anim. s. vert. 2*: 554.

1997. *Anthenea pentagonula*: James, D.B.: *J. mar. biol. Ass. India, 38*: 134.

2007. *Anthenea pentagonula*: Sastry, D.R.K.: *Rec. zool. Surv. India, Occ. Paper* No. *271*: 58.

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay, five specimens, R/r = 19/8, 20/8, 25/12, 28/13, 30/13 (st. 18, October 2006), colour after preservation, pinkish on abactinal, and some actinal plates, others colourless; one specimen R/r = 65/30, colour reddish when live, turned light brown on preservation (st.17, March 2007); one specimen, R/r = 13/6. Nine specimens (st.17) and single specimen (st.18) in November 2007, two specimens (st.18, March 2008).

**Description**: Abactinal side slightly convex, abactinal plates irregularly polygonal, closely packed, covered with uniform granulations, a single enlarged tubercle on some of the abactinal plates only in the largest specimen. Superomarginal plates large, vertically aligned but extending to abactinal side forming a side wall, covered with uniform granulation. Inferomarginal plates with a prominent flat spine on the outer lower margin. Actinal plates parallel to the adambulacrals, covered with uniform granulation and with 1-3 large bivalved pedicellariae conspicuous, particularly on the plates adjacent to the adambulacrals. Adambulacral plates with 6-8 furrow spines, 2-3 subambulacral spines and fine granulation outer to these.

**Remarks**: The smallest specimen from st.17 with poorly developed granulation only on the abactinal side, pedicellariae not yet developed, and very small subactinal spines, appeared to be a juvenile. James (1997) revised the specimens of the genus and gave full synonymy.

**Distribution**: INDIA: Gujarat, Tamil Nadu and Orissa. The species is newly recorded from Andhra Pradesh. ELSEWHERE: Bay of Bengal and South China Sea.

4. ***Goniodiscaster* sp.**

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay (st.18, October 2006); one disc.

**Remarks**: Because of the availability of a single specimen, the specimen could not be identified up to species level.

**Distribution**: INDIA: Orissa (Barwa and Pundi), Gulf of Mannar, Mandapam, Tamil Nadu. *Goniodiscaster* sp. was reported for the first time from Andhra Pradesh coast. ELSEWHERE: Philippine islands, East Indies, Bay of Bengal. *Goniodiscater* sp. was reported for the first time from Andhra Pradesh coast.

**Order**: Spinulosida

**Family**: Echinasteridae

5. ***Echinaster purpureus*** (Gray)

1971. *Echinaster purpureus*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 73 (key), 40-41 (distribution).

2007. *Echinaster purpureus*: Sastry, D.R.K.: *Rec. zool.*

*Surv. India, Occ. Papers*, No. *271*: 82.

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay (st.17, October 2006), one specimen, R/r = 28/6 mm, br = 6 mm, single specimen (st.18, March 2007), three specimens (st.17, November 2007).

**Remarks**: Cylindrical arms with bluntly rounded tips, space between the furrow spines and subambulacral spines, and a single madreporite characterise the specimens.

**Distribution**: INDIA: Gujarat, Tamil Nadu, Orissa and Nicobar Islands. The species is new to Andhra Pradesh. ELSEWHERE: Red Sea, East Africa, Islands of Western Indian Ocean, Mascareen Islands, Maldives and Bay of Bengal.

**Class**: Ophiuroidea
**Order**: Ophiurida
**Family**: Amphiuridae

6. ***Amphioplus* (*Lymanella*) *depressus*** (Ljungman, 1867)

1971. *Amphioplus* (*Lymanella*) *depressus*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 102 (key), 80-81 (distribution).

2007. *Amphioplus* (*Lymanella*) *depressus*: Sastry, D.R.K.: *Rec. zool. Surv. India, Occ. Papers* No. *271*: 135.

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay, 4 specimens (st.1), eight specimens (st.2), seven specimens, d.d. = 5-6 mm, largest arm bit about 20 mm long. Two specimens (sts.3,5,6,7,13,14), seventeen specimens (st.9), three specimens (st.11), single specimen (sts.12,15,18) in October 2006. Four specimens (st.3), three specimens (st.9) in March 2007; single (sts.16,17,19) and two specimens (st.20) in November 2007; four specimens (st.14) in March 2008.

**Remarks**: Radial shields twice as long as broad; oral shield pointed orally, distally elongated and narrow, adoral shields meeting in front of the oral shield, four oral papillae, third larger than fourth, three lateral spines, pointed, smooth, dorsal arm plates broader than long, distal margin convex; ventral arm plates broader than long, two tentacle scales.

**Distribution**: India, ELSEWHERE: Bay of Bengal, East Indies, Philippine Islands, North Australia and South Pacific Islands.

**Family**: Ophiotrichidae

7. ***Ophiocnemis marmorata*** (Lamarck, 1816)

1971. *Ophiocnemis marmorata*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 106 (key), 84-85 (distribution).

2007. *Ophiocnemis marmorata*: Sastry, D.R.K.: *Rec. zool. Surv. India, Occ. Papers* No. *271*: 145.

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay, three specimens (st.1), six specimens (st.2), nine specimens (st.3), one specimen (sts.5,7,12), one specimen (st.17), d.d.=14 mm. Two specimens (sts.6,18), twenty (st.9), five (st.11), four (st.13) in October 2006. Seven (st.9) in March 2007, single (sts.12,20) two (sts.16,17,19) in November 2007, two (st.18) in March 2008.

**Remarks**: The specimens show extremely large radial shields, and naked ventral interradial regions devoid of scales typical of the specimens with disc granulation. The species is a new record from the coast of Andhra Pradesh.

**Distribution**: East Africa and Madagascar, Ceylon, East Indies, North Australia, Philippine Islands, China and South Japan.

8. ***Ophiothrix* sp.**

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay, nine specimens (st.9), two (sts.13,17) in October 2006; single specimen (st.17) in March 2007; single (st.16) in March 2008.

**Remarks**: Because of the bad condition of the arm, the specimens could not be identified with any specimens. However, no specimens of the genus was reported so far, from the coast of Andhra Pradesh

**Class**: Echinoidea
**Order**: Diadematoida
**Family**: Diadematidae

9. ***Chaetodiadema granulatum*** Mortensen, 1903

1971. *Chaetodiadema granulatum*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 152 (key), 140-141 (distribution).

2007. *Chaetodiadema granulatum*: Sastry, D.R.K.: *Rec. zool. Surv. India, Occ. Papers* No. *271*: 164.

**Material**: Andhra Pradesh: Guntur district, off Nizampatnam Bay, 30 m, seven specimens (st.19, November 2007).

**Remarks**: The specimens measure 100-130 mm in diameter and 30-40 mm in height with D = 3.0-3.5H. The test is somewhat flexible. From Andhra Pradesh, the species was earlier known from Srikakulam and Vizianagaram districts.

**Distribution**: India, ELSEWHERE: Red Sea, Maldives, East Indies, North Australia, Philippine Islands, China, South Japan.

**Order**: Temnopleuroida
**Family**: Temnopleuridae

10. ***Salmaciella dussumieri*** (L. Agassiz, 1846)

1971. *Salmaciella dussumieri*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 155 (key), 140-141 (distribution).

2007. *Salmaciella dussumieri*: Sastry, D.R.K.: *Rec. zool. Surv. India, Occ. Papers* No. *271*: 172.

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay, seven specimens (st.18) in October 2006, of which three specimens D/H = 20/7, 20/7 and 23/8 mm respectively. Five specimens (st.9), single (st.14) in October 2006; single (st.9) in March 2007, two (st.17), eight (st.19) in November 2007.

**Remarks**: The specimens show angular pits, primary tubercles one each on every ambulacral plate and primary spines banded green. The species is new record for Andhra Pradesh.

**Distribution**: Islands of the West Indian Ocean, East Africa and Madagascar, Red Sea, South-east Arabia, Ceylon, East Indies, North Australia, Philippine Islands, China and South Japan.

11. ***Salmacis virgulata*** (L. Agsassiz, 1846)

1846. *Salmacis virgulata* Agassiz, L. *In*: Agassiz, L. & E. Desor: *Ann. Sci. nat. (3)6*: 359.

1971. *Salmacis virgulata*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 156 (key), 140-141 (distribution).

2007. *Salmacis virgulata*: Sastry, D.R.K.: *Rec. zool. Surv. India, Occ. Papers* No. *271*: 174.

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay, eight specimens (st.9), single (st.18) in October 2006; single (st.9) in March 2007; single (st.17), four (st.19) in 2007.

**Remarks**: The specimens measure D/H = 50/25 mm. The spines are characteristically violet tipped.

**Distribution**: INDIA: Lakshadweep and Tamil Nadu. The species is newly recorded from Andhra Pradesh. ELSEWHERE: Bay of Bengal, East Indies, Philippine Islands and South China Sea.

12. ***Temnopleurus toreumaticus*** (Leske, 1778)

1971. *Temnopleurus toreumaticus*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 154 (key), 142-143 (distribution).

2007. *Temnopleurus toreumaticus*: Sastry, D.R.K.: *Rec. zool. Surv. India, Occ. Papers* No. *271*: 176.

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay, thirty-two (st.1), two (st.19), fourteen (st.3), single (sts.4,5,19), two (sts.8,9,12) in October 2006; single (sts.1,18) in March 2007; ten (st.15), single (st.19) in November 2007; single (st.3) in March 2008.

**Remarks**: The specimens show large angular pits and crenulated tubercles on the test and pore pairs in arcs of three. The young ones occur in large aggregations in the subtidal depths, particularly around the river mouths.

**Distribution**: East Africa and Madagascar, Red Sea, South-east Arabia, Persian Gulf, West India, Pakistan, Maldives, Ceylon, East Indies, North Australia, Philippine Islands, China and South Japan, South Pacific Islands.

**Order**: Clypeasteroida
**Family**: Clypeasteridae

13. ***Clypeaster humilis*** (Leske, 1778)

1894. *Clypeaster humilis*: Anderson, A.R.S.: *Jour. Asiat. Soc. Beng*, 62 (part II, No. 3): Andhra Pradesh: Numerous specimens from Off Coromandel; Kerala (Malabar Coast) and Sri Lankan coasts, 18-73 m (10-40 fms. (fms depth in fathoms)). The material probably belongs to *Clypeaster reticulatus* or *Clypeaster rarispinus*, there being no material of *C. humilis* available to Koehler (vide infra).

1922. *Clypeaster humilis*: Koehler, R.: Echinoderma of the Indian Museum, part IX: 51. No specimen of Investigator collection from Indian coast was available to Koehler; hence a specimen from Red Sea was described. This makes one doubt the identity of specimens reported by Anderson, 1894 (vide supra).

1971. *Clypeaster humilis*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 161 (key), 144-145 (distribution).

2007. *Clypeaster humilis*: Sastry, D.R.K.: *Rec. zool. Surv. India, Occ. Papers* No. *271*: 186.

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay, one specimen (st.18, October 2006), single specimen (st.17, November 2007), anterior radius = 40 mm, breadth = 70 mm, posterior region broken.

**Remarks**: In view of the non-availability of specimens to Koehler and consequent doubtful identity of specimens from Andhra Pradesh reported by Anderson as noted by Sastry (2007), this is the first report of the specimens from Andhra Pradesh.

**Distribution**: East Africa and Madagascar, Red Sea, South-east Arabia, Persian Gulf, Ceylon, East Indies, North Australia, Philippine Islands, South Pacific Islands.

14. ***Clypeaster rarispinus*** de Meijere, 1903

1971. *Clypeaster rarispinus*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 160 (key), 144-145 (distribution).

2007. *Clypeaster rarispinus*: Sastry, D.R.K.: *Rec. zool. Surv. India, Occ. Papers* No. *271*: 187.

**Material**: Andhra Pradesh, one specimen; Guntur district, Nizampatnam Bay. Three (st.2), single (sts.8,9,11), four (st.14), thirteen (st.15), twenty-nine (st.19) in October 2006; five (sts.1,18), single (st.14), three (st.17) in March 2007. Single (st.15), forty-six (st.17), four (st.18), two

(st.19) in November 2007. Single (st.9), three (st.17) in March 2008. Two specimens (st.19, October 2006), 1 x b = 18 x 22 mm, longer than wide; one specimen (st. 17) in March 2007, 35 x 32 mm; and four specimens (st.17) in November 2007, 45 x 40 mm.

**Remarks**: The species was earlier known from Andhra Pradesh and Orissa coasts.

**Distribution**: East Africa and Madagascar, Red Sea, South-east Arabia, Persian Gulf, west India, Pakistan, Maldives, Ceylon and East Indies.

**Family**: Astriclypeidae

15. ***Echinodiscus auritus*** Leske, 1778

1971. *Echinodiscus auritus*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 162 (key), 144-145 (distribution).

2007. *Echinodiscus auritus*: Sastry, D.R.K.: *Rec. zool. Surv. India, Occ. Papers* No. *271*: 198.

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay, five specimens (st.17 = 95-120 mm), lunules about 35 mm long, single specimen (sts.9,18) in October 2006; two specimens (st.9) in March 2008.

**Remarks**: The species was earlier known from Andhra Pradesh and Orissa coasts.

**Distribution**: Mascarene Islands, East Africa and Madagascar, Red Sea, South-east Arabia, Persian Gulf, West India and Pakistan, Ceylon, East Indies, North Australia, Philippine Islands, China and South Japan.

**Order**: Spatangoida

**Family**: Brissidae

16. ***Brissopsis luzonica*** (Gray, 1851)

1971. *Brissopsis luzonica*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 165 (key), 146-147 (distribution).

2007. *Brissopsis luzonica*: Sastry, D.R.K.: *Rec. zool. Surv. India, Occ. Papers* No. *271*: 205.

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay, single (st.11), six (st.15) in October 2006; single (st.12), six (st.17), ten (st.18) in November 2007; three (st.14), four (st.18), single (st.19) in March 2008 (single specimen from st.19 measured l x b x h = 26 x 20 x 10 mm).

**Remarks**: Along the coast of Andhra Pradesh, the specimens were earlier reported from R.I.M.S. Investigator St. 98. Off Santapalli of Vizianagaram district.

**Distribution**: East Africa, Madagascar, Red Sea, West India, Pakistan, Maldives, East Indies, North Australia, Philippine Islands, China and South Japan, South Pacific Islands, Hawaiian Islands.

**Family**: Spatangidae

17. ***Nacospatangus (Pseudomaretia) alta*** (A. Agassiz, 1863)

1971. *Pseudomaretia alta*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 165 (key), 146-147 (distribution).

2007. *Nacospatangus* (*Pseudomaretia*) *alta*: Sastry, D.R.K.: *Rec. zool. Surv. India, Occ. Papers* No. *271*: 210.

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay, three specimens (sts.9,13,14), two specimens (st.17), five specimens (st.18) in October 2006; two specimens (sts.17,19) in November 2007; single specimen (st.17) in March 2008. One specimen, primary spines only two in a single row in lower area of postero lateral interambs; two specimen (st.18) in October 2006, l x b x h = 30 x 22 x 9 and 33 x 24 x 12 mm respectively.

**Remarks**: The species was earlier known from Andhra Pradesh and Orissa coasts.

**Distribution**: Islands of West Indian Ocean, Mascarene Islands, Maldives, Ceylon, East Indies, Philippine Islands, China and South Japan.

**Family**: Loveniidae

18. ***Loveuia elougata*** (Gray, 1845)

1971. *Lovenia elongata*: Clark, A.M. and F.W.E. Rowe: Monograph of shallow-water Indo-west Pacific echinoderms, 164 (key), 146-147 (distribution).

2007. *Lovenia elongata*: Sastry, D.R.K.: *Rec. zool. Surv. India, Occ. Papers* No. *271*: 211.

**Material**: Andhra Pradesh: Guntur district, Nizampatnam Bay, seven specimens (st.14), four (st.17) in October 2006; single (sts.14,18,20), one specimen, l x b x h = 38 x 30 x 14 mm, highest at posterior inter-ambulacrum, flat and low anterior to apical system.

**Remarks**: The earlier reports of the specimens from India were from Tamil Nadu coast and the locality reported as Coromandel coast which falls within Andhra Pradesh coast is not known. As such, this is the first report of the specimens from Andhra Pradesh.

**Distribution**: East Africa and Madagascar, Red Sea, South-east Arabia, Persian Gulf, Maldives, Ceylon, East Indies, North Australia, Philippine Islands, China and South Japan.

## SUMMARY

During the present study, the asteroid *Astropecten velitaris* is added new to the fauna of India, the asteroids – *Luidia hardwicki*, *Echinaster purpureus* and *Goniodiscaster* sp., the ophiuroids – *Ophiocnemis marmorata*, and *Ophiothrix* sp. and the echinoids – *Salmaciella dussumieri*,

*Salmacis virgulata*, *Clypeaster humilis* and *Lovenia elongata* are new records for Andhra Pradesh.

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# GENETIC DIFFERENTIATION OF ARGALI SHEEP *OVIS AMMON* IN MONGOLIA REVEALED BY MITOCHONDRIAL CONTROL REGION AND NUCLEAR MICROSATELLITES ANALYSES

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The genetic distinctiveness and possible gene flow among the Argali Sheep (*Ovis ammon*) populations in Mongolia have been controversial, due to a high degree of morphological variation among populations and an apparent lack of physical barriers to dispersal. We studied the population genetic structure of Argali sheep in Mongolia using both mitochondrial control region sequences (613 bp) and 14 nuclear microsatellite markers. Mitochondrial results suggest two evolutionarily distinct lineages, one in the Altay Mountains and the other in the Hangay Mountains and eastern Gobi Desert. Microsatellite analysis indicated genetic differentiation among these three regions, and also indicated similar levels of genetic differentiation and gene flow among all pair-wise comparisons. These results suggest genetic differentiation among the Mongolian populations of this endangered mammal.

**Keywords**: Argali sheep, mitochondrial DNA, microsatellites, *Ovis ammon*, population genetic structure

## INTRODUCTION

The Argali Sheep (*Ovis ammon*), which is the largest species of wild sheep in the world, has become endangered due to poaching and habitat destruction (Valdez 1982; U.S. Fish and Wildlife Service 1996). Currently in Mongolia, Argali Sheep are patchily distributed in the Altay Mountains, Hangay Mountains, and Gobi Desert (Mallon 1985). Following a country-wide survey in 2002, Frisina *et al.* (2007) estimated a Mongolian Argali population of about 20,000. Across this range, both elevation and habitat productivity decrease gradually without obvious physical barriers to dispersal (Frisina 1998). Morphologically, Mongolian Argali Sheep is highly variable, and there is a general trend for average body size to decrease as elevation decreases from west to east, with Altay Argali being the largest in body size of all *O. ammon* (Geist 1991).

The variable morphology and the lack of obvious geographic barriers to gene flow have led to a long-debated controversy regarding the taxonomic status of Mongolian Argali and the delineation of genetically distinct populations. Allen (1940) considered all Mongolian Argali to be one subspecies *O.a. darwini*, but currently two subspecies are commonly recognized: *O.a. ammon* (Altay Argali) are large argalis from the Altay mountain region, and *O.a. darwini* (Gobi Argali) are smaller argalis from Gobi desert region (Sopin 1982; Valdez 1982; Geist 1991; Mitchell and Frisina 2007). Detailed analysis of cranial morphology show that *O.a. ammon* and *O.a. darwini* are morphologically distinct from other argalis and from each other, thus supporting subspecific recognition of these taxa (Kapitanova *et al.* 2004). The taxonomic position of argali from the Hangay region of Mongolia is unclear: Sopin (1982) and Geist (1991) considered these argalis to be similar to those from Altay (*O.a. ammon*), but genetic analyses by Tserenbataa *et al.* (2004) suggest that they may be more closely allied to Gobi argalis (see below).

Although a species of conservation concern, at present little is known about population structure and gene flow among argali populations in Mongolia. Tserenbataa *et al.* (2004) examined genetic variation at the mitochondrial ND5 locus, and found little genetic differentiation among populations in Mongolia and nearby regions of Kazakhstan and Kyrgyzstan. What little genetic differentiation they did find appeared to separate Gobi/Hangay from Altay/Kazakhstan/Kyrgyszstan. Tserenbataa *et al.* (2004) attributed the lack of genetic differentiation to high levels of female-mediated gene flow among populations, and concluded that argali populations from all of Mongolia and nearby regions of China and Russia should be considered a single "evolutionary significant unit" (or subspecies) with two management units.

The conclusions of Tserenbataa *et al.* (2004) contrasts with those from morphometric analyses, which suggest two argali subspecies in Mongolia (Kapitanova *et al.* 2004). Moreover, the shallow ND5 phylogenetic tree presented by Tserenbataa *et al.* (2004) suggests that the lack of genetic differentiation among populations may be due to incomplete lineage sorting rather than to the movement of individuals

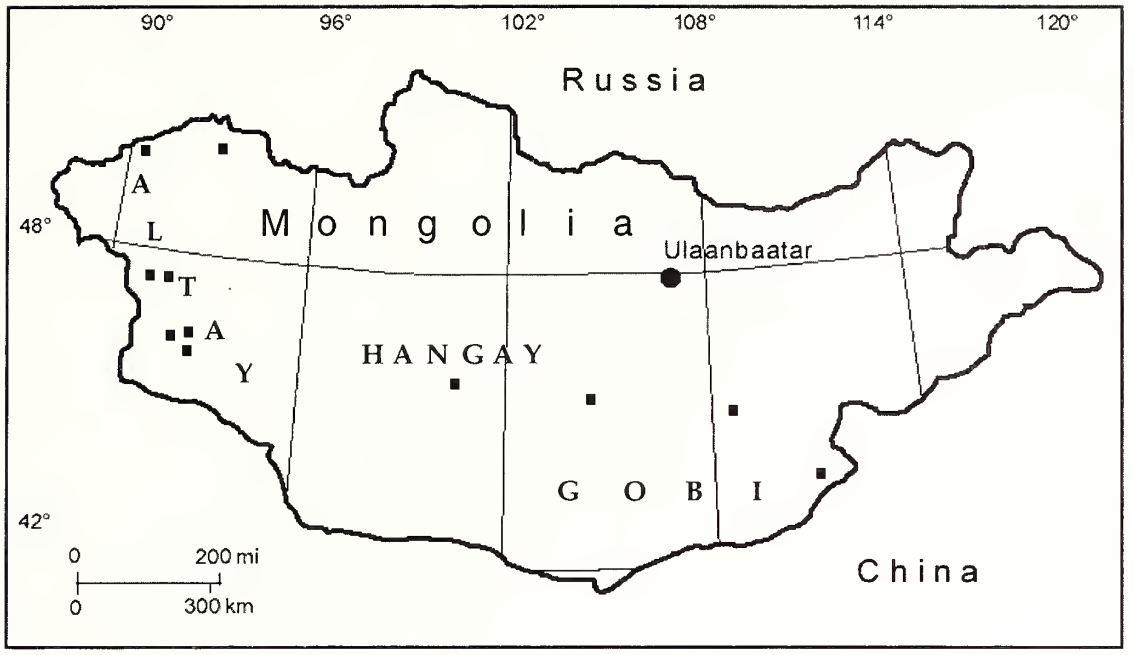


Fig. 1: Geographic distribution of sampling locations (filled squares) in Mongolia

(Avise 2000). To help resolve this taxonomic controversy and aid in conservation efforts, we studied two molecular genetic markers that show relatively high evolutionary rates – the mitochondrial control region and nuclear microsatellites – for argali samples collected in Mongolia.

**Abbreviations**: mtDNA = mitochondrial DNA, MP = maximum parsimony, ML = maximum likelihood, ME = minimum evolution

## MATERIAL AND METHODS

We collected a total of 58 argali samples from Altay Mountains, Hangay Mountains and eastern Gobi Desert in Mongolia (Fig. 1), including tissue samples (skin and liver) collected from legally hunted individuals and bone samples (horn fragments and teeth) collected from carcasses found in the field. Skin samples of Snow Sheep (*Ovis nivicola*) from Russia were collected to serve as an outgroup for phylogenetic comparisons. Despite considerable and repeated efforts to extract and amplify DNA from all sources, some sources (e.g., some bone samples from carcasses) proved difficult and did not yield usable DNA. Consequently, the sample sizes for mtDNA and microsatellite analyses (see below) differ from each other and from the total number of samples collected.

We used a standard proteinase K digestion and phenol/chloroform methods to extract genomic DNA (Sambrook *et al.* 1989). The mtDNA control region was amplified via polymerase chain reaction (PCR) using primers modified for ungulates (Murray *et al.* 1995), and sequenced the portion proximal to $tRNA^{PRO}$ via cycle sequencing (Feng *et al.* 2001). Replicate amplifications were sequenced for most samples, and replicates always yielded identical results. Moreover, all sequences were clean and easily scored, suggesting that we did not co-amplify nuclear paralogs or encounter heteroplasmy. All haplotype sequences have been deposited in Genbank (accession numbers AY315886-AY215899). We used maximum parsimony, maximum likelihood, and minimum evolution approaches for phylogenetic analyses of the control region haplotypes (details given below). These analyses were conducted using PAUP*4.0b2 (Swofford 1998).

We screened 37 pairs of primers of dinucleotide-repeat microsatellites developed from domestic sheep (Crawford *et al.* 1995) in 10 argali individuals, and found 14 loci to be polymorphic: ILS5, ILS56, MAF33, MAF36, MAF48, MAF64, MAF209, FCB128, FCB226, FCB304, OHH35, OHH56, OVH72, and OVH116. Published primers and annealing temperatures (Crawford *et al.* 1995) to amplify alleles under the following conditions: 10 µl total reaction volume containing 20-50 µg genomic DNA, 1x PCR buffer (Roche), 0.05 mM dNTPs, 0.05 mM of each primer, 3.0 mM $MgCl_2$, 0.5U Taq polymerase, and 15 µCi $^{33}$P-dATP (to label alleles). The PCR program was 94 °C for 3 min, followed by 35 cycles of 94 °C for 1 min, annealing temperature for 1 min, and 72 °C for 45 sec. The last cycle was followed by a 5 min

extension at 72 °C. We separated PCR products by electrophoresis through a 6% polyacrylamide gel and ran a M13 sequence standard along with our PCR products for sizing the alleles. As with sequence analyses, replicates were amplified and electrophoresed for most samples to ensure accuracy of results.

For each population, the program GENEPOP web version 3.1c (Raymond and Rousset 1995a) was used to calculate genetic diversity for each locus, as well as the mean observed heterozygosity across all loci. Global tests of both allelic and genotypic distributions were performed to detect population differentiation. $F_{st}$ (calculated using FSTAT 1.2, Goudet 1995) rather than $R_{st}$ was used to measure population differentiation because the former performs better when sample size is small (Gaggiotti *et al.* 1999). The genetic distance calculator at http://www.biology.ualberta.ca was also used to calculate pair-wise Nei's genetic distances between populations. At the individual level, we conducted assignment tests (Paetkau *et al.* 1995; Waser and Strobeck 1998) using the calculator available at http://www.biology.ualberta.ca. We also calculated the pair-wise allele-sharing genetic distance (Bowcock *et al.* 1994) matrix, which was then subjected to PAUP*4.0b2 (Swofford 1998) and multidimensional scaling analysis in two dimensions (Manly 1997) with SPSS to test whether genetic similarity reflects geographic groupings.

## RESULTS

**Mitochondrial Control Region Phylogeny**: We obtained 14 argali control region haplotypes from 17 sequences. We aligned 613 bp (including indels), of which 92 (15.0%) were variable (Fig. 2), and 32 of these were parsimony informative. The maximum likelihood estimate of transition/transversion ratio was 3.4:1. Base frequencies did not differ significantly across taxa ($\chi^2 = 23.07$, df = 45, p = 0.997), with A = 38.9%, C = 21.8%, G = 11.3%, and T = 28.0%. The sequence data contained significant phylogenetic signal as indicated by both a permutation test (PTP test, 1000 replicates, $p < 0.001$), and a tree length skewness test (*g1* test, 10,000 random trees, $p < 0.01$). Hierarchical likelihood ratio tests indicated that the optimal sequence evolution model for our observed data was the HKY+G model, which incorporates unequal base frequencies, unequal transition vs. transversion rates, and among site rate heterogeneity. The rate heterogeneity distribution parameter was $\alpha = 0.56$ (S.E. = 0.10), and the total heterogeneity (Gu *et al.* 1995) was 0.64.

Four maximum parsimony (MP) trees were found through a branch and bound search. Maximum likelihood (ML) and minimum evolution (ME) analyses yielded tree topologies that were concordant with the strict consensus MP tree (Fig. 3). The tree topology indicated that haplotypes from Hangay and east Gobi are more closely related to each other than they are to those from Altay. Seven out of eight haplotypes from Altay formed a single well-supported clade ("Altay group"). Haplotypes from Hangay and Gobi, plus a single haplotype from southern Altay, formed another well-supported clade ("Hangay/Gobi group"). Pair-wise ML genetic distance between the Altay group and Hangay/Gobi group (5.32% ±0.08%) was greater than that within the Altay (1.19% ±0.13%) and Hangay/Gobi groups (0.67% ±0.07%). Factoring out intra-group variation, the average ML genetic distance between the two groups was 4.39%.

**Microsatellite Diversity and Differentiation**: We obtained microsatellite genotype data at 14 loci for a total of

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          0000001111111111111111111111122222222222222222222233334444444444445555555555555555555556666
          0177991277777777778888999999990000000000113346777882356012233356889001226667778899999990011
          8325081501234567890123234567890123456789390431145678831338901752452237050182585891234579460 1
7M(A)     ATTTCGCTGCTCACATAACAACCCATACAGAAAAGCACAATCACTTAGGATGTCAATCGTTAC-TAACCCAGTAAAGTATAG-CATTTACCC
M3(A)     -CC..AT.....................................C.GTCCGAAGCACTG.CT-G.GTT.....T.....TAC.........A..A.
M6(A)     .CC..ATC....................................C.GTCCGAAG.ACTG.C...-GTT...T.......TAC.........-..A.
M7(A)     .CC..A......................................C.GTCCGAAG.ACTG.CT-G.GTT.....T...-.TAC.........-..A.
M9(A)     .CC..AT.....................................C.GTCCGAAG.ACTG.CT-G.GTT.........-.TAC...AG....A..A.
M19(A)    .CC.TA..-----------------------------------C.GTCCGAAG.ACTG.CT-G.G.T....TT.....TAC.........-T.A.
M20(A)    .CCC.A.....................................TGTCCGAA..ACTG.CT-G.GTTGT...T.....TAC.........AGAA.
M21(A)    .CC..A......................................C.GTCCGAA..ACTG.CT-G.GTT.....T.....TAC..T.....A..-.
M13(H)    .C.....................................................C.C..GC.-G..TT.-G....A.-.TA..C.....C.A..A.
M14(H)    .C.....................................................C.C..GC.-G..TT.-G...GA...TA..C.....C.A..A.
M15(H)    .C.....................................................C.C..GC.CG..TT..G....A.-.TA..C..CACC.A..A.
M17(H)    .C.....................................................C.C..GC.-G..TT.-G....AG..TA..C.....CGG..-.
M18(H)    .C.....................................................C.C..GC.-G..TT.-G...-A...TA.TC.....C.A...T
Arg2(G)   .C.....................................................C.C..GC.-G..TT..G....A..GTAC.......C.A..A.
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Fig. 2: Sequence alignment of polymorphic nucleotide sites for Argali control region haplotypes

Note: Numbers along the top refer to positions in the consensus sequence; Sample names are given in the extreme left column; and letters in parentheses refer to sampling location (A = Altay, H = Hangay, and G = Gobi); the top row gives the sequence for a reference sample (7M); dots indicate nucleotides that are identical to the reference; and dashes indicate deletions

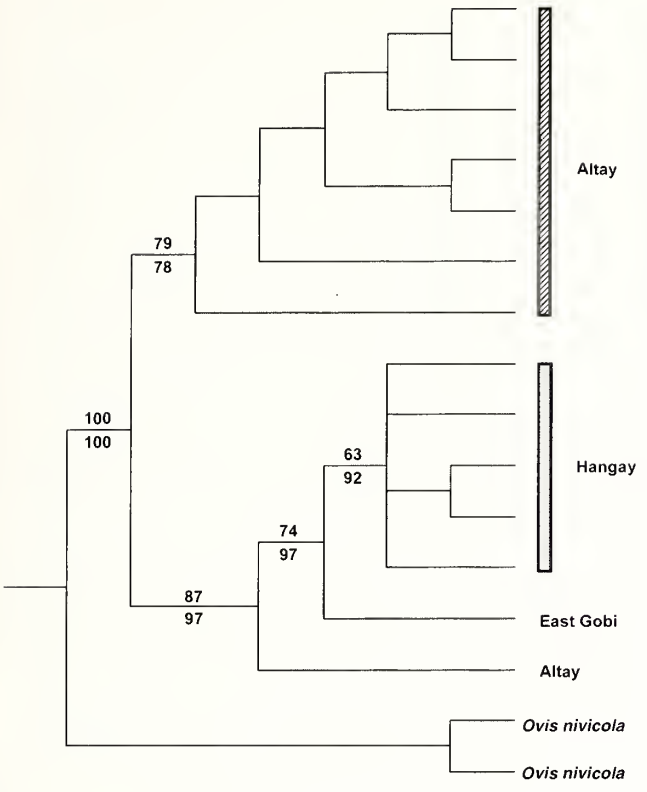


Fig. 3: Strict consensus tree of four most parsimony trees (tree length 343, CI = 0.904, RI = 0.907, RC = 0.820) rooted with snow sheep (*Ovis nivicola*). Transversion: transition ratio was 3:1, gaps were treated as a fifth state, and the branch and bound search algorithm was used. Numbers above the branches indicate the bootstrap values obtained through 1000 replications (only values above 50% are shown). The maximum likelihood tree had an identical topology, and numbers below branches indicate quartet puzzling support values (only values above 50% are shown)

30 individuals (12 from Altay, 11 from Hangay, and 7 from Gobi). There were no significant deviations from Hardy-Weinberg equilibrium (U tests, Raymond and Rousset 1995b), and no significant linkage disequilibrium (Fisher exact tests).

The total number of alleles for a locus across populations ranged from 4 to 13 (mean = 7.5, S.E. = 0.79), and observed heterozygosity ranged from 0.30 to 0.77 (mean = 0.61, S.E. = 0.04). For Altay, Hangay, and Gobi populations, the average number of alleles per locus (± S.E.) was 5.9 (±0.47), 5.0 (±0.47), and 3.6 (±0.36) respectively, and the mean observed heterozygosity was 0.61 (± 0.04), 0.65 (± 0.06), and 0.53 (± 0.07) respectively.

Fisher's exact test conducted on microsatellite allele and genotype frequencies showed significant population differentiation (P<0.001). The mean $F_{st}$ for all loci was 0.056 (S.D. = 0.017), which was significantly greater than zero (permutation test with 1000 replications, P < 0.001). Pair-wise $F_{st}$ values were similar across population pairs (range: 0.051 to 0.056), as were Nei's pair-wise genetic distances (range: 0.213 to 0.272). Likelihood assignment tests yielded a high percentage of correct assignments (26 of 30, 87%). For Gobi, all of 7 individuals were assigned to Gobi. For Altay, 10 of 12 individuals were assigned to Altay, 1 was assigned to Hangay, and 1 was assigned to Gobi. For Hangay, 9 of 11 individuals were assigned to Hangay, 1 was assigned to Altay, and 1 was assigned to Gobi. The percentage of correct assignment was significantly higher than expected by chance ($\chi^2 = 25.6$, df = 1, $p < 0.005$), suggesting significant differences in genotype frequencies among examined populations. However, the allele-sharing genetic distance matrix failed to generate geographic clustering of individuals, and multi-dimensional scaling showed a poor fit of data into two dimensions (Stress = 0.30, $R^2 = 0.53$).

## DISCUSSION

**Genetic Differentiation of Argalis in Mongolia**: Due to a lack of apparent topographic boundaries and yet highly variable morphology across populations, controversy surrounds the level of genetic differentiation among Mongolian argali populations (Allen 1940; Sopin 1982; Valdez 1982; Geist 1991). This controversy has continued in large part due to the difficulties of obtaining genetic samples from the remote range of this species, and these difficulties also limited the sample size of our own analyses. Nevertheless, despite the limited sample size, our analyses of both mtDNA control region and nuclear microsatellites revealed significant genetic differentiation among sampled argali populations in Mongolia.

The mtDNA control region phylogeny revealed two major groups – one composed of individuals from Altay and the other comprised primarily of individuals from Hangay/Gobi – with an average sequence divergence (4.39%) similar to that observed between subspecies in other large mammals (Douzery and Randi 1997; Wooding and Ward 1997; Arctander *et al.* 1999; Matsuhashi *et al.* 1999), and greater than that typically seen among populations of Bighorn Sheep (*Ovis canadensis*; Ramey 1995; Luikart and Allendorf 1996; Boyce *et al.* 1999). This is also consistent with the speculation that habitat differences and a subtle geographic barrier (the Alakhnur Depression) have led to a reproductive isolation between Argali Sheep living in the Altay Mountains and those living in the Gobi desert (Sopin 1982). Interestingly, one Altay haplotype grouped with, but was basal to, the Gobi/Hangay group. Though this might be due to a low level of gene flow between the regions, incomplete lineage sorting seems a more plausible explanation.

Within the Hangay/Gobi group, all Hangay haplotypes formed one monophyletic subgroup and the single Gobi haplotype was positioned outside this Hangay group. Although this suggests some differentiation between Hangay and Gobi, additional samples from Gobi are required to further address the phylogenetic relationship between these populations.

Our nuclear microsatellite results also indicated significant genetic differentiation among the sampled populations. Although our sample sizes were small, the observed $F_{st}$ value of 0.056 is similar to that found among natural populations of other large mammals (Roy *et al.* 1994; Forbes and Hogg 1999; Paetkau *et al.* 1999; Gutiérrez-Espeleta *et al.* 2000). Moreover, although the individual allele-sharing genetic distance matrix did not generate meaningful geographic groupings (probably due to small sample size) the high percentages of "correct" assignments yielded in the likelihood assignment test suggest that allele frequency distributions differ among the three populations. Furthermore, the similar pair-wise $F_{st}$ and genetic distances and the even distribution of unassigned individuals suggest that these three populations are approximately equally differentiated from each other.

**Implications for Argali Taxonomy**: Currently, two subspecies of argali are commonly recognized in Mongolia (Sopin 1982; Valdez 1982; Geist 1991): *O.a. ammon* (Altay mountain region) and *O.a. darwini* (Gobi desert region). These subspecific designations are supported by morphometric analyses (Kapitanova *et al.* 2004), and our mitochondrial control region phylogeny supports the distinction between argali from these regions. In contrast, although Hangay argalis are currently classified as *O.a. ammon* based on morphological similarities (Sopin 1982; Geist 1991), our mitochondrial analyses instead suggests that Hangay argalis are more closely related to *O.a. darwini* than to *O.a. ammon* (Tserenbataa *et al.* 2004).

There are two possible explanations for this discrepancy. First, the more ammon-like morphology of Hangay argali may be due to the higher habitat productivity of the Hangay region relative to the arid Gobi desert. Second, because the mtDNA phylogeny only represents maternal descent, Hangay argali may be a hybrid form resulting from matings between large-bodied *ammon* males and small-bodied *darwini* females. This 'hybrid origin' hypothesis also can explain the approximately equal genetic distances that we obtained from nuclear microsatellite data. One way to test this hypothesis is to use a Y-linked marker to reconstruct the paternal lineage of Mongolian argalis. Moreover, since we were able to obtain only one sequence from Gobi argali, it is possible that the Hangay and Gobi populations represent two distinct subspecies of argali; this possibility requires further testing with additional haplotypes.

**Implications for Conservation Management**: Our mtDNA results showed that Mongolian argali haplotypes can be divided into two reciprocally monophyletic groups – one consisting of haplotypes found only in the Altay Mountains, and the other consisting almost exclusively of haplotypes from the Hangay Mountains and eastern Gobi desert. Due to the presence of one Altay haplotype in the Hangay/Gobi clade, argali in these two regions are not strictly reciprocally monophyletic, and therefore do not fit the definition of Evolutionary Significant Units (ESU's) suggested by Moritz (1994). Nevertheless, our mtDNA results suggest two distinct, independent lineages, and the ESU criterion suggested by Moritz (1994) has been criticized for being overly stringent (Crandall *et al.* 2000; Fraser and Bernatchez 2001). Therefore, we tentatively recommend that argali in Altay and Hangay/Gobi be treated as two separate ESU's for conservation purposes.

Our microsatellite analyses indicated significant nuclear genetic differentiation among all three regions of Mongolia. Our mitochondrial control region analyses also showed differentiation between our single Gobi haplotype and all Hangay haplotypes, with the latter forming a single monophyletic clade. These results suggest that each area should be treated as a separate management unit (Moritz 1994) for conservation purposes. However, this recommendation should be considered tentative because sample sizes and areas surveyed were limited in this study (particularly for mitochondrial analyses), and because microsatellites can sometimes show significant differentiation across populations that may not be biologically meaningful (Hedrick 1999).

Our results are mostly consistent with the mitochondrial ND5 analyses of Tserenbataa *et al.* (2004), who found significant genetic differentiation between the Altay and Hangay/Gobi regions. However, Tserenbataa *et al.* (2004) found that the differentiation between these two groups was relatively weak, that there was no significant differentiation between Hangay and Gobi populations, and that haplotypes from any region did not form a monophyletic group. Tserenbataa *et al.* (2004) concluded that there has been significant historical gene flow among the three regions of Mongolia and nearby areas of China and Russia, and that the entire region should be treated as a single ESU/subspecies. Our results indicate that the lack of resolution in the ND5 data of Tserenbataa *et al.* (2004) likely is due to the slow evolutionary rate of ND5 (compared to the control region and nuclear microsatellites) and incomplete lineage sorting rather than to the movement of individuals between regions. Nevertheless, studies that combine large sample sizes (as in Tserenbataa *et al.* 2004) with more sensitive genetic markers (as in this study) are needed before making firm conclusions about conservation units for Mongolian and other argali.

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# ROTIFER COMMUNITIES OF FLOODPLAIN LAKES OF MANIPUR (NORTH-EAST INDIA): BIODIVERSITY, DISTRIBUTION AND ECOLOGY

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The rotifer communities of fifteen slightly acidic-circumneutral, soft water floodplain lakes (*pats*) of Manipur, with low ionic concentrations; revealed 151 species of Rotifera belonging to 42 genera and 22 families. Biogeographically interesting elements include two Australasian, four Oriental, eight Palaeotropical, one Holarctic and one Arctic-temperate species. Cosmopolitan species form a notable component (67.5%) while Cosmotropical > Pantropical species are well-represented. Lecanidae (40 species) > Lepadellidae (25 species) > Trichocercidae (15 species) > Brachionidae (14 species) comprise an important fraction (62.25%) of the documented species The rotifer fauna is characterised by dominance of *Lecane* spp., occurrence of several acidophilus species, paucity of *Brachionus* spp. and general tropical character. Richness ranges between 62 and 120 (73 ±14) species in individual *pats*, registers 53.0-87.9% community similarities (*vide* Sorensen index) and shows wider seasonal variations (29-79 species) in different *pats*. The rotifers form an important quantitative component (mean: 45.9-58.8%) of zooplankton in all lakes. ANOVA indicates a significant temporal variation of richness and density between lakes and seasons. Richness is inversely correlated with water temperature. The density is inversely correlated with specific conductivity and alkalinity, and positively correlated with hardness. Canonical analysis registers moderate and relatively higher cumulative impact of six abiotic factors on richness and density respectively. The rotifer communities of the sampled *pats* are characterised by relatively high species diversity, lower dominance and higher evenness.

**Key words**: Floodplain lakes, Manipur, Rotifera, biodiversity, distribution, ecology

## INTRODUCTION

The floodplain lakes, an integral part of various riverine systems of the world, harbour the richest aquatic biodiversity and are considered to be the most productive freshwater biotopes (Odum 1978; Mitsch and Gosselink 1986). They form an important inland aquatic resource of India in general, and that of N.E. India in particular. The floodplain lakes, commonly called '*pats*' in Manipur, are located in the Iral, Imphal and Thoubal river basins. They cover an area of 16,500 ha and play a vital role in the socio-economic development of the state because of their significant biogenic production potential. These interesting ecotones are facing severe environmental stress due to general habitat degradation, influx of waste water and encroachment of land for expanding human settlements, and increasing pressures for converting them into agricultural lands. Hence, conservation of these valuable wetlands and of their biological diversity deserves priority attention.

The investigations on aquatic biodiversity in India began nearly a century ago. The published literature indicates limited information on composition and ecology of invertebrate, and zooplankton communities in the floodplain lakes of this country (Sharma and Sharma 2008). The studies on zooplankton diversity of the floodplain lakes of N.E. region in particular, are mainly initiated in beels of the Brahmaputra basin (Sharma and Sharma 2001, 2008; Sharma 2005). On the other hand, the contributions in the floodplain lakes of Manipur are so far restricted to a preliminary unpublished list of Shyamananda Singh (1991) and new records of Rotifera (Sharma 2007).

The present study on Rotifera, the most diverse group of zooplankton, of the floodplain lakes or '*pats*' of Manipur, therefore, assumes special biodiversity and ecological interest. The rotifer communities of fifteen lakes of this state are analyzed with reference to species richness, community similarities, and general nature and composition of their taxocoenosis. Remarks are made on biogeographically interesting elements and on distribution of various species. In addition, variations in richness and abundance are recorded and comments are made on species diversity, dominance, evenness and ecology of Rotifera.

## MATERIAL AND METHODS

The observations were undertaken in fifteen floodplain lakes (*pats*) of the Iral, Imphal and Thoubal river basins (24° 25'-24° 45' N; 93° 45'-94° 00' E), located in Bishnupur, Imphal and Thoubal districts of Manipur respectively (Table 1).

Water samples collected seasonally from different *pats*, during the study period November 2002-October 2003, were analyzed for water temperature, specific conductivity, pH, dissolved oxygen, alkalinity and hardness. Plankton samples were collected seasonally for qualitative (by towing) and

**Table 1**: Districts of Manipur representing floodplain lakes (*pats*) selected for the study area

| Sr. No. | Name of Lake (*pat*) | District |
|---|---|---|
| 1 | Loktak | Bishnupur / Imphal |
| 2 | Waithou | Thoubal |
| 3 | Utra | Bishnupur |
| 4 | Sana | Bishnupur |
| 5 | Lakoi | Bishnupur |
| 6 | Takmu | Bishnupur |
| 7 | Ikop | Thoubal |
| 8 | Kharung | Thoubal |
| 9 | Khoidum | Thoubal |
| 10 | Pumlen | Thoubal |
| 11 | Lousi | Thoubal |
| 12 | Karam | Thoubal |
| 13 | Ngagua | Thoubal |
| 14 | Tankha | Imphal |
| 15 | Lamphel | Imphal |

quantitative (by filtering 25 litre water) analysis from various lakes with a nylobolt plankton net (mesh size: 50 µm), during the study period, and were preserved in 5% formalin. The Rotifera species were identified following Koste (1978), Segers (1995), Sharma (1998a), and Sharma and Sharma (1999, 2000, 2008). Remarks on the distribution were made *vide* Segers (2007). Quantitative plankton samples were analyzed for enumeration of the rotifer densities (n/l).

Community similarities (Sorensen index), species diversity (Shannon index), dominance (Berger-Parker index) and evenness (Pileou index) were calculated following Ludwig and Reynolds (1988) and Magurran (1988). The significance of temporal variations of richness and densities were ascertained by ANOVA. Canonical analysis (STATISTICA version 5.0) was undertaken for simple and multivariate correlations.

## RESULTS AND DISCUSSION

Water temperature (13.1-30 °C) affirms the subtropical nature of different *pats*. Specific conductivity (36.0-200 µS/cm) shows low ionic concentrations (Table 2) and warrants their inclusion under 'Class I' category of 'trophic classification' of Talling and Talling (1965). All the sampled *pats* are characterised by slightly acidic-circumneutral waters (pH: 5.70-6.92) with mean pH values ranging between 6.02-6.44. Dissolved oxygen ranges between 2.4-12.0 mg/l.

Rotifers form the most diverse qualitative group of zooplankton in all the lakes in the study area and include a total of 151 species, which comprise 39.7% of the Indian Rotifera and 70% of the species known from N.E. India. Further, this study exhibits higher diversity, i.e., 42 genera and 22 families of this Phylum known till date from floodplain lakes or other aquatic ecosystems of India. This salient feature deserves special mention in view of 46 and 67 genera, as well as 24 and 25 families, of Eurotatoria respectively so far reported from N.E. India (Sharma, unpublished). The present results reflect rich, speciose and diverse nature of Rotifera and, hence, reflect greater environmental heterogeneity of the sampled *pats*. These features concur with the composition of the rotifer communities of the floodplains of Argentina (Jose de Paggi 1993), South America (Bonecker *et al.* 1998) and Australia (Shiel *et al.* 1998). This study affirms the hypothesis of Segers *et al.* (1993) indicating (sub) tropical floodplains to be the world's richest habitats for rotifers, and also endorses earlier studies (Sharma 2005; Sharma and Sharma 2008) in the floodplain lakes of the Brahmaputra river basin.

The Rotifera biodiversity of the sampled lakes is lower than the reports of 207, 218 and 252 species from the floodplain lakes of Africa (Segers *et al.* 1993), South America (Bonecker *et al.* 1998) and Australia (Shiel *et al.* 1998) respectively. The richness however, is marginally lower than the 164 species examined from fifteen floodplain lakes from the Brahmaputra river basin of Assam (Sharma 2005) while it is higher than 127 species listed from other fifteen beels of Assam (Sharma and Sharma 2008). The present report of the rotifer richness in the floodplain lakes of Manipur, however, is distinctly higher to the records of 64 species (Sharma 2000), 29 species (Goswami 1997) and 48 species (Sarma 2000) from the beels of Assam and 43 species (Khan 2003) from the floodplains of south-east West Bengal.

Interestingly, Loktak lake – a Ramsar site and one of the largest freshwater wetlands of India, exhibits the highest Rotifera richness (120 species) known till date from any individual aquatic ecosystem of the Indian subcontinent in general and floodplain lake, in particular. The numbers also exceed the recent highest record of 110 species (Sharma and Sharma 2005b) from Deepor beel, a Ramsar site and another important wetland of N.E. India. Rotifera richness of Loktak compares well with the report of 124 species from Oguta lake of Niger delta (Segers *et al.* 1993); 111 species (Jose de Paggi 1993) and 114 species (Jose de Paggi 2001) examined from floodplain lakes of Argentina; 136 species from Iyi-Efi lake of the Niger delta (Segers *et al.* 1998); and 130 species from Lake Guaraná, Brazil (Bonecker *et al.* 1994).

The present study reveals sixteen biogeographically interesting species (10.6%) belonging to the following categories:

1. Australasian species: *Macrochaetus danneeli* and *Notommata spinata*

2. Oriental species: *Filinia camasecla*, *Lecane acanthinula*, *L. blachei* and *L. solfatara*

3. Palaeotropical species: *Euchlanis semicarinata*, *Lecane lateralis*, *L. simonneae*, *L. unguitata*, *Lepadella bicornis*, *L. discoidea*, *Testudinella brevicaudata* and *Trichocerca abilioi*

4. Arctic-Temperate: *Lecane scutata*

5. Holarctic: *Lecane elongata*

The report of two Australasian species, a notable feature of this study, depicts an interesting affinity between the rotifer faunas of the N.E. India with that of South-east Asia and Australia. Of these, *Macrochaetus danneeli* is reported from Australia and Thailand. Segers and Sarma (1993) mentioned its occurrence in southern India based on an unpublished report, but the record from Assam (Sharma 2004) indicates its only confirmed report from India and second report from Asia. *Notommata spinata*, resurrected as a distinct species by Koste and Shiel (1991), occurs in Australia and is now known from India only from Assam (Sharma 2005).

The occurrence of four Oriental species is another salient feature of the rotifer fauna of the sampled *pats*. Among these, *Filinia camasecla* and *Lecane solfatara* are so far known only from N.E. India (Sharma and Sharma 2008), *L. blachei* is reported from Eastern and North-east India and *L. acanthinula* exhibits disjunct distribution in this country with reports from Southern and North-Eastern India (Sharma and Sharma 2005a).

Amongst the Palaeotropical species, the erstwhile Afro-tropical *Euchlanis semicarinata* examined from Loktak lake, Manipur (Sharma 2007) is an interesting recent addition to the Indian Rotifera. *Lecane simonneae* is reported from India only from Tripura (Sharma and Sharma 1997) while *Lepadella discoidea*, *Testudinella brevicaudata* and *Trichocerca abilioi* are known from Assam in N.E. India. *Lecane lateralis*, described originally from West Bengal (Sharma 1978), is a widely known palaeotropical element. *Lepadella bicornis*, described by Vasisht and Battish (1971) from Chandigarh, north India is known only from Brazil; its recent record from Assam (Sharma and Sharma *in press*) represents the second Indian report of this lecanid since its description. *Lecane unguitata* is widely distributed in India.

**Table 2**: Abiotic factors of *pats* of Manipur

| Abiotic Factors | Water temp. (° C) | Specific conductivity (µS/cm) | pH | Dissolved oxygen (mg/l) | Alkalinity (mg/l) | Hardness (mg/l) |
|---|---|---|---|---|---|---|
| Loktak | 14.2-28.5 (21.8 ±4.2) | 66.0-132.0 (93.3 ±17.1) | 5.70-6.92 (6.31 ±0.32) | 4.2-9.0 (5.7 ±1.1) | 10.0-41.2 (19.1 ±7.1) | 24.0-54.0 (38.3 ±7.8) |
| Waithou | 14.5-29.2 (21.6 ±4.8) | 52.0-120.5 (92.3 ±16.8) | 5.59-6.60 (6.21 ±0.28) | 2.4-12.0 (5.3 ±2.8) | 10.0-36.2 (19.7 ±5.6) | 20.1-56.0 (33.6 ±7.8) |
| Utra | 16.2-27.9 (22.2 ±3.5) | 48.0-120.5 (77.2 ±21.6) | 5.40-6.68 (6.23 ±0.32) | 4.0-10.0 (6.0 ±1.4) | 10.0-44.0 (19.5 ±9.4) | 20.0-46.0 (33.0 ±7.4) |
| Sana | 13.1-28.5 (21.2 ±5.2) | 69.3-107.0 (80.2 ±8.3) | 6.12-6.78 (6.37 ±0.14) | 4.8-7.9 (5.4 ±2.6) | 25.1-38.5 (29.2 ±4.1) | 19.2-32.5 (25.9 ±3.7) |
| Lakoi | 14.5-29.0 (22.1 ±4.9) | 41.8-82.0 (61.4 ±5.9) | 6.15-6.81 (6.37 ±0.12) | 5.2-9.0 (6.6 ±2.2) | 12.0-36.0 (24.2 ±4.9) | 10.0-34.2 (20.4 ±4.6) |
| Takmu | 15.1-28.2 (22.6 ±3.1) | 79.5-128.0 (100.5 ±8.6) | 5.89-6.86 (6.02 ±0.34) | 4.2-10.0 (5.8 ±2.1) | 16.0-39.4 (21.4 ±5.3) | 15.4-48.0 (24.9 ±5.1) |
| Ikop | 13.9-21.6 (21.3 ±5.5) | 124.1-200.0 (168.7 ±13.9) | 6.18-6.77 (6.39 ±0.12) | 4.0-9.2 (6.9 ±1.8) | 22.3-50.0 (30.4 ±5.9) | 18.0-48.4 (24.9 ±5.8) |
| Kharung | 14.0-28.5 (21.0 ±4.0) | 36.0-68.0 (46.0 ±5.1) | 5.91-6.89 (6.30 ±0.29) | 6.0-9.0 (7.2 ±1.6) | 26.2-48.0 (32.4 ±4.2) | 22.0-44.2 (30.0 ±4.7) |
| Khoidum | 12.4-27.6 (22.8 ±4.7) | 72.4-100.0 (87.9 ±7.2) | 5.92-6.62 (6.22 ±0.13) | 4.4-8.4 (5.8 ±2.1) | 21.4-32.6 (25.8 ±3.9) | 14.0-29.4 (18.3 ±3.3) |
| Lousi | 14.5-27.9 (21.7 ±4.1) | 94.2-149.0 (121.2 ±9.0) | 6.12-6.89 (6.44 ±0.14) | 5.2-10.4 (6.5 ±2.6) | 12.0-35.4 (24.1 ±4.3) | 14.0-36.0 (23.9 ±3.7) |
| Karam | 12.9-28.0 (20.7 ±4.1) | 78.1-108.0 (80. 8 ±6.7) | 5.72-6.48 (6.16 ±0.10) | 4.2-8.8 (6.4 ±1,2) | 18.4-29.4 (23.1 ±2.1) | 16.2-28.0 (21.1 ±3.2) |
| Ngagua | 14.0-29.2 (22.2 ±3.6) | 105.4-183.0 (134.2 ±16.7) | 6.12-6.78 (6.43 ±0.11) | 5.6-7.8 (6.4 ±1.3) | 20.1-38.8 (32.2 ±3.9) | 16.2-29.6 (20.7 ±3.9) |
| Tankha | 14.0-29.0 (22.0 ±4.0) | 87.0-125.0 (105.1 ±6.6) | 6.01-6.77 (6.37 ±0.13) | 6.2-9.6 (6.8 ±2.4) | 25.2-48.0 (30.3 ±4.0) | 16.8-39.1 (26.0 ±4.4) |
| Lamphel | 13.5-28.7 (21.4 ±3.5) | 153.0-200.0 (177.4 ±9.3) | 6.12-6.86 (6.38 ±0.12) | 5.4-9.8 (6.0 ±2.5) | 18.4-38.0 (27.8 ±4.2) | 16.8-36.2 (26.2 ±4.2) |
| Pumlen | 13.5-30.0 (21.5 ±4.2) | 98.4-127.0 (107.8 ±5.3) | 5.82-6.78 (6.26 ±0.16) | 6.2-9.0 (7.0 ±1.8) | 12.5-37.4 (21.6 ±4.3) | 10.2-30.2 (20.6 ±3.7) |

Note: Mean values given in parentheses

**Table 3**: Rotifera of floodplain lakes (*Pats*) of Manipur

| Recorded taxa \ Floodplain lakes | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Order**: Ploima | | | | | | | | | | | | | | | | |
| **Family**: Brachionidae | | | | | | | | | | | | | | | | |
| *Anuraeopsis fissa* Gosse | + | - | + | - | - | + | - | + | + | - | - | + | + | + | - | R |
| *Brachionus angularis* Gosse | + | + | + | + | + | + | + | + | - | + | + | - | + | + | + | C |
| *B. bidentatus* Anderson | - | - | + | + | + | - | + | + | - | - | + | + | + | - | + | C |
| *B. calyciflorus* Pallas | + | - | - | - | - | - | - | - | - | + | + | - | - | - | - | R |
| *B. diversicornis* (Daday) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + | R |
| *B. falcatus* Zacharias | + | + | + | + | + | + | + | + | + | - | + | - | + | + | + | C |
| *B. forficula* Wierzejski | - | - | - | + | - | - | - | - | - | - | - | + | - | - | - | R |
| *B. mirabilis* Daday | + | - | + | - | - | - | + | + | + | + | - | + | - | - | + | R |
| *B. quadridentatus* Hermann | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *Keratella cochlearis* (Gosse) | + | + | + | - | + | - | + | + | + | + | + | + | + | + | + | C |
| *K. lenzi* Hauer | - | - | - | - | - | + | - | - | - | - | + | - | - | - | - | R |
| *K. tropica* (Apstein) | + | - | - | + | + | + | - | + | + | + | - | + | + | + | - | C |
| *Platyias quadricornis* (Ehrenberg) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *Plationus patulus* (O.F. Müller) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *P. patulus macracanthus* (Daday) | + | + | + | - | - | + | + | + | + | + | + | - | + | + | - | C A |
| **Family**: Epiphanidae | | | | | | | | | | | | | | | | |
| *Epiphanes brachionus* (Ehrenberg) | - | - | - | - | - | - | - | + | - | - | - | - | - | - | - | R |
| **Family**: Euchlanidae | | | | | | | | | | | | | | | | |
| *Euchlanis dilatata* Ehrenberg | + | + | + | - | + | + | + | + | + | - | + | + | + | + | + | C |
| *E. incisa* Carlin | - | - | - | + | + | - | + | + | + | + | - | + | + | + | + | R |
| *E. oropha* Gosse | - | - | - | + | - | - | + | + | - | - | + | - | + | - | - | R |
| *E. semicarinata* Segers | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | R |
| *E. triquetra* Ehrenberg | + | + | + | + | - | + | + | - | + | + | - | + | + | - | + | R A |
| *Dipleuchlanis propatula* (Gosse) | + | + | + | + | - | + | + | + | + | - | + | + | - | + | - | C A |
| *Beauchampiella eudactylota* (Gosse) | + | - | + | - | + | + | + | + | - | + | + | + | + | + | + | C |
| **Family**: Mytilinidae | | | | | | | | | | | | | | | | |
| *Lophocharis salpina* (Ehrenberg) | + | - | + | - | + | - | - | - | - | - | - | - | - | - | - | R |
| *Mytilina bisulcata* (Lucks) | + | + | - | - | - | - | - | + | - | - | + | + | - | + | - | R A |
| *M. ventralis* (Ehrenberg) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| **Family**: Trichotriidae | | | | | | | | | | | | | | | | |
| *Macrochaetus danneeli* Koste & Shiel | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | R |
| *M. longipes* Myers | + | + | - | + | + | - | + | - | + | + | + | + | - | - | + | R |
| *M. sericus* (Thorpe) | + | + | + | - | - | + | + | + | - | - | - | + | + | + | - | C |
| *Trichotria tetractis* (Ehrenberg) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| **Family**: Lepadellidae | | | | | | | | | | | | | | | | |
| *Colurella adriatica* Ehrenberg | - | - | - | + | - | - | - | + | + | - | + | - | - | + | - | R |
| *C. obtusa* (Gosse) | + | + | + | - | - | + | + | + | + | + | + | + | + | + | + | C |
| *C. sulcata* (Stenroos) | + | - | - | + | + | - | - | + | - | - | - | - | - | + | + | R A |
| *C. uncinata* (O.F. Müller) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C A |
| *Lepadella acuminata* (Ehrenberg) | + | + | + | - | - | + | + | + | + | + | + | + | + | + | + | C |
| *L. apsicora* Myers | + | - | - | + | + | + | + | + | - | - | + | - | + | - | + | R |
| *L. apsida* Harring | + | + | + | - | + | - | + | + | + | - | - | - | + | + | + | R |
| *L. bengamini* Harring | + | - | - | - | - | - | - | - | - | - | + | - | - | - | - | R |
| *L. bicornis* Vasisht & Battish | + | - | - | + | - | - | - | - | - | - | - | - | - | - | - | R |
| *L. biloba* Hauer | - | - | - | - | - | - | - | - | - | - | - | + | - | - | - | R |
| *L. costatoides* Segers | + | - | - | - | - | - | - | + | - | + | - | - | + | - | - | R |
| *L. cristata* (Rousselet) | - | - | - | + | - | - | + | - | - | - | - | + | - | + | - | R A |
| *L. dactyliseta* (Stenroos) | + | - | - | + | + | - | - | - | - | + | - | + | - | + | - | R |
| *Lepadella discoidea* Segers | - | - | - | + | - | + | - | - | - | - | + | - | - | - | - | R |

**Table 3**: Rotifera of floodplain lakes (*Pats*) of Manipur (*contd.*)

| Recorded taxa \ Floodplain lakes | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *L. ehrenbergi* (Perty) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *L. eurysterna* Myers | + | - | - | - | + | - | - | + | + | - | + | - | + | - | + | R |
| *L. heterostyla* (Murray) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *L. latusinus* (Hilgendorf) | - | - | - | - | - | - | - | - | - | - | - | - | + | - | - | R |
| *L. lindaui* Koste | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | R |
| *L. ovalis* (O.F. Müller) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *L. patella* (O.F. Müller) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *L. rhomboides* (Gosse) | + | + | + | - | - | + | + | + | + | + | + | + | + | + | + | C |
| *L. triba* Myers | - | + | - | - | - | - | - | - | - | - | - | - | - | - | - | R |
| *L. triptera* Ehrenberg | + | + | + | - | - | + | + | + | - | + | + | + | - | + | + | R A |
| *Squatinella mutica* (Ehrenberg) | + | - | - | + | + | - | + | + | - | - | - | + | + | + | - | R |
| **Family**: Lecanidae | | | | | | | | | | | | | | | | |
| *Lecane acanthinula* (Hauer) | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | R |
| *L. aculeata* (Jakubski) | + | + | + | - | - | - | - | + | + | - | + | + | + | + | + | R |
| *L. blachei* Berzins | + | - | - | + | - | - | - | - | + | - | - | - | + | - | + | R |
| *L bulla* (Gosse) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *L. closterocerca* (Schmarda) | + | + | + | - | + | + | + | + | - | + | + | + | + | + | + | C |
| *L. crepida* Harring | + | + | + | + | - | + | + | + | + | + | + | + | + | + | + | C |
| *L. curvicornis* (Murray) | + | + | + | - | + | + | - | + | + | + | + | + | + | + | + | C |
| *L. decipiens* (Murray) | - | - | - | + | - | - | - | - | - | - | - | - | - | - | - | R |
| *L. doryssa* Harring | + | - | - | + | - | - | - | - | - | - | - | - | - | - | - | R A |
| *L. elegans* Harring | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | R |
| *L. elongata* Harring & Myers | - | - | - | - | - | - | - | + | - | - | - | - | - | - | - | R |
| *L. flexilis* (Gosse) | + | - | + | - | + | + | - | + | - | - | + | - | + | - | + | R |
| *L. furcata* (Murray) | + | + | + | + | - | - | - | - | + | - | + | - | + | + | + | R |
| *L. haliclysta* Harring & Myers | - | - | + | - | - | - | - | - | - | - | - | - | - | - | - | R |
| *L. hamata* (Stokes) | + | + | + | - | + | - | + | + | + | + | - | + | + | + | + | C |
| *L. hastata* (Murray) | - | - | - | + | - | + | - | - | - | + | - | - | - | - | + | R |
| *L. hornemanni* (Ehrenberg) | + | + | + | + | + | + | - | + | + | + | + | + | + | + | + | C |
| *L. inermis* (Bryce) | + | + | + | + | + | + | + | + | + | - | - | + | + | + | - | C |
| *L. inopinata* Harring & Myers | + | - | - | - | - | + | - | - | + | - | - | + | - | - | + | R |
| *L. lateralis* Sharma | + | - | - | - | + | - | + | - | - | - | - | + | - | - | - | R |
| *L. leontina* (Turner) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *L. ludwigii* (Eckstein) | + | + | + | + | - | + | + | - | + | + | - | - | - | + | - | R |
| *L. luna* (O.F. Müller) | + | + | + | - | + | - | + | + | + | + | + | + | + | - | + | C |
| *L. lunaris* (Ehrenberg) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *L. monostyla* (Daday) | + | + | - | + | - | - | - | - | + | - | - | - | + | + | - | R |
| *L. obtusa* (Murray) | + | + | + | - | - | - | - | + | - | - | + | - | - | - | + | R |
| *L. ohioensis* (Herrick) | + | + | + | - | - | - | + | - | - | - | - | + | - | + | - | R |
| *L. papuana* (Murray) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *L. ploenensis* (Voigt) | + | + | + | - | - | + | + | + | + | - | + | + | + | + | - | C |
| *L. quadridentata* (Ehrenberg) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *L. ruttneri* Hauer | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | R |
| *L. scutata* (Harring & Myers) | - | - | - | - | + | - | + | - | - | - | - | - | + | - | - | R A |
| *L. signifera* (Jennings) | + | + | + | + | + | + | + | + | - | + | - | + | + | + | + | C |
| *L. simonneae* Segers | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | R |
| *L. solfatara* (Hauer) | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | R |
| *L. stenroosi* (Meissner) | + | + | + | + | - | + | + | + | + | + | + | + | - | + | + | C |
| *L. tenuiseta* Harring | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | R |
| *L. thienemanni* (Hauer) | - | - | - | + | + | - | + | - | - | - | - | - | + | - | + | R |
| *L. unguitata* (Fadeev) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *L. ungulata* (Gosse) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |

**Table 3**: Rotifera of floodplain lakes (*Pats*) of Manipur (*contd.*)

| Recorded taxa \ Floodplain lakes | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Family**: Notommatidae | | | | | | | | | | | | | | | | |
| *Cephalodella forficula* (Ehrenberg) | + | + | - | + | - | + | + | - | - | + | + | + | + | - | + | R |
| *C. gibba* (Ehrenberg) | + | + | - | - | + | + | - | + | - | - | - | + | - | - | + | R |
| *C. mucronata* Myers | + | - | - | - | + | - | + | + | - | - | - | - | - | - | - | R |
| *Monommata longiseta* (O.F. Müller) | + | - | - | + | - | - | - | - | + | + | - | + | + | + | - | R A |
| *M. maculata* (Harring & Myers) | + | - | - | - | - | + | - | - | + | - | - | - | - | - | + | R A |
| *Monommata* sp. | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | R |
| *Notommata spinata* Koste & Shiel | + | - | - | - | - | - | - | + | - | - | - | - | + | - | - | R |
| *Taphrocampa annulosa* (Gosse) | - | - | - | - | - | - | - | - | - | - | - | - | - | + | - | R |
| **Family**: Scaridiidae | | | | | | | | | | | | | | | | |
| *Scaridium longicaudum* (O.F. Müller) | + | + | + | - | - | + | + | + | + | + | + | + | + | + | + | C |
| **Family**: Gastropodidae | | | | | | | | | | | | | | | | |
| *Ascomorpha ecaudis* Perty | + | - | - | + | - | - | - | - | - | - | - | - | + | - | - | R |
| *A. ovalis* (Bergendal) | - | - | - | - | - | - | + | - | - | - | - | - | - | - | - | R |
| **Family**: Trichocercidae | | | | | | | | | | | | | | | | |
| *Trichocerca albiloi* Segers & Sarma | + | - | - | - | - | - | - | + | - | - | - | - | - | - | - | R |
| *T. bicristata* (Gosse) | + | - | - | - | + | + | - | - | - | - | - | - | - | - | - | R |
| *T. capucina* (Wierzejski & Zacharias) | - | - | - | - | - | - | - | - | + | - | - | - | - | - | - | R |
| *T. cylindrica* (Imhof) | + | + | + | + | - | - | + | + | + | + | + | + | + | + | + | C |
| *T. elongata* (Gosse) | + | + | - | + | - | - | - | + | - | + | - | + | + | - | - | R |
| *T. flagellata* Hauer | + | - | - | - | + | - | - | - | - | - | + | - | - | - | - | R |
| *T. insignis* (Herrick) | + | - | - | + | - | + | - | - | - | - | - | - | + | - | - | R |
| *T. jenningsi* Voigt | + | + | - | + | - | - | - | - | + | - | - | - | - | - | + | R |
| *T. longiseta* (Schrank) | + | + | + | + | + | - | + | + | + | + | - | + | - | + | - | C |
| *T. pusilla* (Jennings) | - | - | - | - | - | - | - | - | - | + | - | - | - | - | - | R |
| *T. rattus* (O.F. Müller) | + | + | + | - | + | + | + | + | + | + | + | - | + | - | + | C |
| *T. ruttneri* Donner | - | - | - | - | - | - | - | - | - | - | + | - | - | - | - | R |
| *T. similis* (Wierzejski) | + | + | + | - | + | - | + | + | + | - | + | + | + | + | + | C |
| *T. sulcata* (Jennings) | - | - | - | - | - | - | - | - | - | - | + | - | - | - | - | R |
| *T. tenuior* (Hudson & Gosse) | + | - | - | - | + | - | - | + | - | - | - | - | - | + | - | R |
| **Family**: Asplanchnidae | | | | | | | | | | | | | | | | |
| *Asplanchna priodonta* Gosse | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| **Family**: Synchaetidae | | | | | | | | | | | | | | | | |
| *Pleosoma lenticulare* Herrick | + | - | - | - | + | - | - | + | - | - | + | - | - | - | - | R |
| *Polyarthra vulgaris* Carlin | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *Synchaeta pectinata* Ehrenberg | + | - | - | + | - | - | - | - | - | - | - | - | + | - | - | R |
| *S. oblonga* Ehrenberg | - | - | - | - | + | - | - | - | - | - | - | - | - | - | - | R |
| **Family**: Dicranophoridae | | | | | | | | | | | | | | | | |
| *Dicranophorus caudatus* (Ehrenberg) | + | - | - | - | - | - | - | + | - | - | - | - | - | + | + | R |
| *D. forcipatus* (O.F. Müller) | + | - | - | + | - | - | - | - | - | - | + | - | - | - | - | R |
| **Order**: Flosculariaceae | | | | | | | | | | | | | | | | |
| **Family**: Flosculariidae | | | | | | | | | | | | | | | | |
| *Floscularia ringens* (Linnaeus) | + | - | - | - | - | - | + | - | - | - | - | - | - | - | - | R |
| *Sinantherina socialis* (Linnaeus) | + | + | - | - | + | + | + | - | + | + | + | + | + | - | + | C |
| *S. spinosa* (Thorpe) | + | + | - | + | + | + | + | + | + | + | + | + | + | - | + | C |
| **Family**: Conochilidae | | | | | | | | | | | | | | | | |
| *Conochilus unicornis* Rousselet | + | + | + | - | - | + | + | + | + | + | - | + | + | + | + | C |

**Table 3**: Rotifera of floodplain lakes (*Pats*) of Manipur (*contd.*)

| Recorded taxa \ Floodplain lakes | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Family**: Trochosphaeridae | | | | | | | | | | | | | | | | |
| *Filinia brachiata* (Rousselet) | + | - | - | + | - | - | - | - | - | - | - | - | - | - | - | R |
| *F. camasecla* Myers | + | - | - | - | + | - | + | - | + | - | - | - | - | - | + | R |
| *F. longiseta* (Ehrenberg) | + | + | + | + | + | + | - | + | + | + | - | + | + | + | + | C |
| *F. opoliensis* (Zacharias) | + | + | + | - | - | + | - | + | - | + | - | + | - | - | - | R |
| *F. saltator* (Gosse) | + | - | - | + | - | - | + | - | - | - | + | - | - | - | - | R |
| *Trochosphaera aequatorialis* Semper | - | - | - | - | - | + | - | - | - | - | - | - | - | - | - | R |
| **Family**: Testudinellidae | | | | | | | | | | | | | | | | |
| *Testudinella brevicaudata* Yamamoto | + | - | - | - | - | - | + | + | - | - | - | - | - | - | - | R |
| *T. emarginula* (Stenroos) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C A |
| *T. parva* (Ternetz) | + | - | - | - | - | - | - | + | + | + | - | + | - | + | - | R A |
| *T. patina* (Hermann) | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | C |
| *T. tridentata* Smirnov | + | + | + | - | - | - | - | - | - | + | + | - | - | - | + | R A |
| **Order**: Collothecaceae<br>**Family**: Collothecidae | | | | | | | | | | | | | | | | |
| *Collotheca ornata* (Ehrenberg) | - | - | - | + | - | - | - | - | - | - | - | - | - | - | - | R |
| **Order**: Bdelloidea<br>**Family**: Adinetidae | | | | | | | | | | | | | | | | |
| *Adineta vaga* (Davis) | - | - | - | - | - | - | - | - | - | - | - | - | + | - | - | R |
| **Family**: Habrotrochidae | | | | | | | | | | | | | | | | |
| *Habrotrocha angusticollis* (Murray) | + | - | - | - | + | - | - | - | - | - | - | - | - | - | - | R |
| **Family**: Philodinidae | | | | | | | | | | | | | | | | |
| *Macrotrachela multispina* Thompson | - | - | - | - | + | - | - | - | - | - | - | - | - | - | - | R |
| *Philodina citrina* (Ehrenberg) | + | + | - | - | - | - | - | - | - | + | - | - | - | - | + | R |
| *Rotaria macroceros* (Gosse) | - | - | - | + | - | - | - | - | - | - | - | - | - | - | - | R |
| *R. neptunia* (Ehrenberg) | + | + | + | - | - | - | - | + | - | - | + | + | - | + | - | R |
| *R. rotatoria* (Pallas) | + | - | + | + | - | - | - | + | + | - | + | - | + | - | + | R |
| *R. tardigrada* (Ehrenberg) | + | - | - | + | - | - | - | - | - | - | - | - | - | - | - | R |
| No. of Species of Rotifera | 120 | 68 | 66 | 69 | 63 | 62 | 70 | 82 | 67 | 62 | 70 | 72 | 75 | 70 | 73 | |

1-Loktak *Pat*, 2-Waithou *Pat*, 3-Utra *Pat*, 4-Sana *Pat*, 5-Lakoi *Pat*, 6-Takmu *Pat*, 7-Ikop *Pat*, 8-Kharung *Pat*, 9-Khoidum *Pat*, 10-Lousi *Pat*, 11-Karam *Pat*, 12-Ngagua *Pat*, 13-Tankha *Pat*, 14-Lamphel *Pat*, 15-Pumlen *Pat*.
'+' Present, '-' Absent, C-Common, R-Rare, A-Acidophilus

Of the two other biogeographically interesting species, *Lecane scutata* is distributed in India in the states of Assam, Meghalaya, Tripura and West Bengal (Sharma and Sharma 2008) while the Holarctic *L. elongata* is recorded recently (Sharma and Sharma *in press*) from Assam.

Lecanidae (40 species) > Lepadellidae (25 species) > Trichocercidae (15 species) > Brachionidae (14 species), in the stated order, comprise an important fraction (62.25%) of the rotifer diversity. The qualitative significance of these eurotatorian families broadly concurs with the results from the floodplains of South America (Jose de Paggi 1993, 2001; Bonecker *et al.* 1994, 1998; Segers *et al.* 1998), Africa (Segers *et al.* 1993) and Thailand (Sanoamuang 1998). This generalization, however, differs from the floodplains of Assam (Sharma 2005; Sharma and Sharma 2008) in occurrence of a fewer species of the Brachionidae. Besides, six other monogonont families namely Notommatidae > Euchlanidae > Trochosphaeridae > Philodinidae = Testudinellidae, together, form a valuable component (21.2%) of Rotifera of the *pats* of Manipur.

Cosmopolitan species form an important component (65.6%) of the rotifer diversity while Cosmotropical > Pantropical species together comprise 23.6%. The members of the last two categories as well as qualitative dominance of 'tropic-centered' genus *Lecane* impart a 'tropical character' to the rotifer fauna of the floodplain lakes of Manipur. This feature concurs with the composition of the tropical faunas from different parts of the globe (Green 1972; Pejler 1977;

Fernando 1980; Dussart *et al.* 1984; Segers 1996; Sharma 1998b). In general, the lecanid dominance compares well with the floodplain rotifer communities studied by Segers *et al.* (1993, 1998), Sanoamuang (1998) and Jose de Paggi (2001). The present results are, however, characterised by distinct paucity of an important tropic-centered' genus *Brachionus* which, in turn, includes only eight species and a number of them even exhibit rare or restricted occurrence; these features are attributed to slightly acidic-circumneutral character of the sampled *pats*. In addition, the rotifer communities show importance of *Lepadella* (20 species) > *Trichocerca* (15 species). Thus, the four mentioned monogonont genera comprise the bulk of species reported from the floodplain lakes of Manipur (83 species, 53%). On the other hand, the occurrence of fewer species of 'temperate-centered' *Keratella* (3 species) and cold-water *Synchaeta* (2 species) and, the lack of any member of *Notholca* are noteworthy.

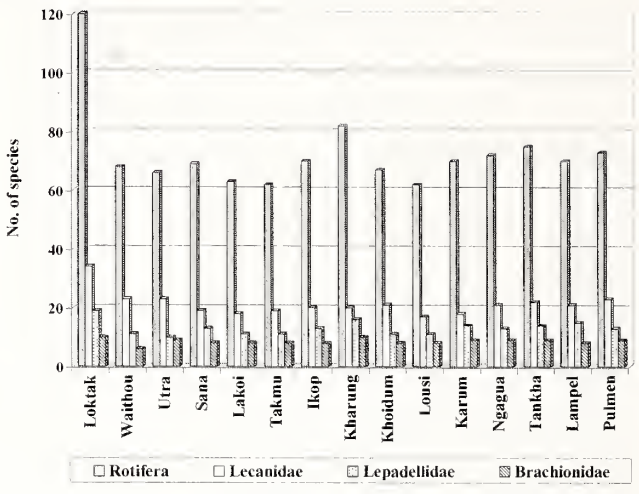


Fig. 1: Species richness of Rotifera and dominant families

This study indicates occurrence of fifteen (9.9%) acidophilus elements, namely *Plationus patulus macracanthus*, *Dipleuchlanis propatula*, *Euchlanis triquetra*, *Mytilina bisulcata*, *Colurella sulcata*, *Lepadella acuminata*, *L. cristata*, *L. triptera*, *Lecane doryssa*, *L. pertica*, *L. scutata*, *Monommata longiseta*, *M. maculate*, *Testudinella emarginula*, *T. parva* and *T. tridentata*. Fifty-one species (23.8%) exhibit common occurrence with 21 species (13.9%) occurring in all the *pats* (Table 3). On the other hand, 101 species (66.0%) show restricted occurrence while 24 (15.9%) of them are rare elements. The rotifer communities of the *pats* of Manipur register 74.5% similarity (*vide* Sorensen's index) with the species known from the beels of Assam. The differences are apparently due to distinct paucity of the Brachionidae in general, and *Brachionus* spp. in particular. Strikingly, lack of species of *Hexarthra*, *Pompholyx* and *Horaella*, and rare nature species of *Conochilus*, *Trochosphaera* and *Filinia* are noteworthy features of the present observations.

The rotifer communities are characterised by the occurrence of a high number of small taxa although species of the higher size classes are also noticed. The former interesting feature may be assigned to conditions of low concentrations of food, and predation by fish and invertebrates as suggested by Papinski (1990) and Baumgartner *et al.* (1997) respectively, but specific investigations are desired to confirm these remarks. The predominance of the littoral periphytic

**Table 4**: Percentage similarities between Rotifer communities (Sorensen's index)

| Floodplain lakes | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Loktak | - | 65.7 | 64.3 | 57.6 | 60.4 | 64.0 | 63.0 | 72.0 | 65.0 | 61.4 | 62.3 | 66.3 | 67.6 | 65.3 | 67.0 |
| Waithou | | - | 87.9 | 61.2 | 62.5 | 76.6 | 77.9 | 76.2 | 79.7 | 78.1 | 77.0 | 82.6 | 75.7 | 80.0 | 79.1 |
| Utra | | | - | 53.0 | 65.1 | 73.0 | 83.6 | 87.4 | 77.9 | 77.8 | 75.2 | 79.4 | 78.3 | 81.2 | 77.4 |
| Sana | | | | - | 57.8 | 54.4 | 63.2 | 57.1 | 64.7 | 60.9 | 59.2 | 60.9 | 60.0 | 63.7 | 60.4 |
| Lakoi | | | | | - | 63.9 | 72.3 | 69.5 | 64.6 | 62.3 | 63.6 | 65.1 | 71.6 | 65.1 | 70.7 |
| Takmu | | | | | | - | 70.8 | 70.9 | 67.7 | 73.8 | 68.2 | 74.2 | 71.6 | 71.3 | 73.4 |
| Ikop | | | | | | | - | 76.5 | 71.1 | 72.3 | 70.1 | 77.1 | 74.6 | 73.0 | 75.2 |
| Kharung | | | | | | | | - | 74.0 | 73.8 | 74.3 | 78.1 | 78.4 | 81.1 | 75.0 |
| Khoidum | | | | | | | | | - | 72.4 | 65.7 | 75.9 | 74.8 | 74.6 | 74.6 |
| Lousi | | | | | | | | | | - | 66.7 | 78.8 | 71.6 | 69.8 | 75.5 |
| Karam | | | | | | | | | | | - | 67.6 | 70.9 | 66.2 | 72.8 |
| Ngagua | | | | | | | | | | | | - | 75.0 | 80.6 | 71.3 |
| Tankha | | | | | | | | | | | | | - | 73.7 | 80.8 |
| Lamphel | | | | | | | | | | | | | | - | 68.6 |
| Pumlen | | | | | | | | | | | | | | | - |

1-Loktak *Pat*, 2-Waithou *Pat*, 3-Utra *Pat*, 4-Sana *Pat*, 5-Lakoi *Pat*, 6-Takmu *Pat*, 7-Ikop *Pat*, 8-Kharung *Pat*, 9-Khoidum *Pat*, 10-Lousi *Pat*, 11-Karam *Pat*, 12-Ngagua *Pat*, 13-Tankha *Pat*, 14-Lamphel *Pat*, 15-Pumlen *Pat*

species and presence of fewer planktonic elements in the examined collections may be attributed to the lack of definite pelagic habitats (De Manuel 1994) in the floodplain lakes. Besides, the occurrence of both planktonic and non-planktonic taxa in the *pats* with marginal vegetation suggests the occupation of different niches (Bonecker *et al.* 1998).

Total Rotifera richness (Fig. 1) in different Manipur lakes varies between 62 and 120, (73 ±14 species); it shows relatively broad range while mean value corresponds with the earlier reports of 67-103 (79 ±11 species) and 69-92 (75 ±6 species) from the beels of the Brahmaputra river basin (Sharma 2005; Sharma and Sharma 2008). The present results are, however, significantly higher than the reports of 24-35 (30 ±4) species and 54-65 (56 ±3) species recorded from five (Sharma 2000) and seven beels (Sharma and Sharma 2001) of Assam respectively. Lecanidae (21 ±4 species) > Lepadellidae (13 ±2 species) > Brachionidae (8 ±1 species) together contribute notably (Fig. 1) to the faunal diversity in individual *pats*. The rotifer communities of the different lakes indicate 53.0-87.9% similarity (*vide* Sorensen index). The peak similarity is noticed between Waithou and Utra *pats* while lowest value is observed between Utra and Sana *pats*. Further, Sana *pat* records the lowest similarity range (53.0-64.7%). Only 5.7% and 6.7% of instances in the matrix (Table 4) indicate similarity values < 60% and > 80% respectively, while in majority of instances (87.6%) the similarity varies between 60-80%. The cluster analysis (Fig. 2) reflects higher similarities in the Rotifera of Waithou and Utra *pats*, Ngagua and Lamphel *pats* and, Tankha and Pumlen *pats*, while Karam, Loktak, Lakoi and Sana *pats* are categorized by differences in their species composition.

Richness depicts significant temporal variations in different seasons ($F_{3.59} = 12.603$, $P < 0.005$) and in different *pats* ($F_{14.59} = 5.585$, $P < 0.005$). Further, it shows notable variations (29-79 species) in individual lakes in different seasons with maximum richness during winter (10 *pats*) and autumn (5 *pats*) (Table 5). The last aspect is affirmed by significant inverse correlation between richness and water temperature (r = -0.441). Canonical analysis registers moderate cumulative influence of six abiotic factors (R = 0.529) on richness. Peak mean richness is noticed during winter (52 ±9 species), followed by 49 ±6 species during autumn while summer and monsoon communities record (34 ±4 species) lowest mean richness. The stated features are in contrast to higher richness reported during summer in the beels of the Brahmaputra basin (Sharma 2005).

Rotifer abundance is apparently low (58-188, 68 ±18 - 125 ±25 n/l) and it registers significant temporal variations between the *pats* ($F_{14.59} = 15.601$, $P < 0.005$), as well as between seasons ($F_{3.59} = 4.345$, $P < 0.005$). Relatively higher densities noticed in Loktak *pat* (84-188 n/l) and Waithou *pat* (87-198 n/l) are yet notably lower than their counterparts from Assam state (Sharma 2005). The rotifers comprise an important quantitative component (mean: 45.9-58.8%) of zooplankton in all lakes and, hence, correspond with the results of Sharma (2005) and Sharma and Sharma (2008), but differ from sub-dominant quantitative role reported by Sharma (2000). Rotifera abundance is inversely correlated with conductivity (r = -0.410) and alkalinity (r = -0.657) and is positively correlated with hardness (r = 0.614). Canonical analysis registers higher cumulative influence of six abiotic factors (R = 0.855) on abundance.

The rotifer communities of Manipur lakes indicate relatively higher species diversity (2.768 ±0.092 - 3.760 ±0.232) than their counterparts of Assam (Sharma 2005). Interestingly, Loktak lake (a Ramsar site) exhibits highest

**Table 5**: Seasonal variations in Rotifera richness

| Lakes | Autumn | Winter | Summer | Monsoon | Range | Total Richness | Mean ± SD |
|---|---|---|---|---|---|---|---|
| Loktak | 60 | 79 | 41 | 43 | 41-79 | 120 | 53 ± 15 |
| Waithou | 40 | 55 | 34 | 37 | 34-55 | 68 | 41 ± 5 |
| Utra | 45 | 40 | 32 | 28 | 28-45 | 66 | 36 ± 5 |
| Sana | 55 | 49 | 35 | 30 | 30-55 | 69 | 42 ± 10 |
| Lakoi | 42 | 48 | 29 | 34 | 29-48 | 63 | 38 ± 7 |
| Takmu | 47 | 40 | 30 | 32 | 30-47 | 62 | 37 ± 7 |
| Ikop | 46 | 50 | 33 | 35 | 33-50 | 70 | 41 ± 7 |
| Kharung | 52 | 59 | 31 | 40 | 31-59 | 82 | 45 ± 11 |
| Khoidum | 48 | 54 | 38 | 32 | 30-54 | 67 | 43 ± 8 |
| Lousi | 42 | 49 | 30 | 33 | 30-49 | 62 | 38 ± 8 |
| Karam | 52 | 48 | 37 | 31 | 31-52 | 70 | 42 ± 8 |
| Ngagua | 45 | 51 | 30 | 35 | 30-51 | 72 | 40 ± 8 |
| Tankha | 58 | 60 | 40 | 31 | 31-60 | 75 | 47 ± 12 |
| Lamphel | 46 | 51 | 35 | 30 | 30-51 | 70 | 40 ± 8 |
| Pumlen | 60 | 55 | 41 | 35 | 35-60 | 73 | 48 ± 10 |

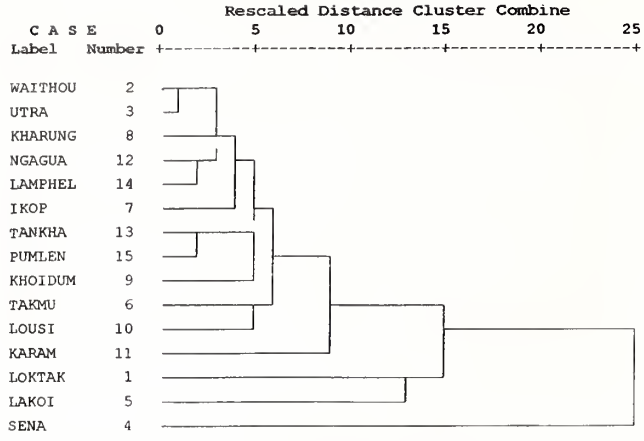


Fig. 2: Dendrogram showing hierarchial cluster analysis of Rotifer communities of different lakes of Manipur

species diversity (Table 6). The notable feature of higher species diversity with relatively lower densities of a large number of species observed in the present study may be ascribed to fine niche portioning amongst rotifer species in combination with high micro- and macro-scale habitat heterogeneity, especially in littoral environments as hypothesized by Segers (2008). Further, the present observations exhibit lower Rotifera dominance (mean: 0.069-0.114) signifying quantitative influence of fewer species (Table 6). The stated feature is re-affirmed by their higher evenness in various *pats* (mean 0.879-0.953) indicating an equitable abundance of different species (Table 6). Dominance is inversely correlated with density (r = -0.709). Evenness is inversely correlated with dominance (r = -0.926) while it is positively correlated with density (r = 0.575). The salient features of lower dominance and higher evenness concur with earlier remarks of Sharma (2000, 2005) and Sharma and Sharma 2008).

## CONCLUSION

To sum up, Rotifera exhibit rich and diverse taxocoenosis with typical tropical character, show occurrence of several biogeographically interesting and acidophilus species and, form main qualitative and quantitative component of zooplankton in all the sampled *pats*. Richness and abundance register significant temporal variations between *pats* and seasons, record limited influence of individual abiotic factors while multivariate analysis indicates moderate and relatively higher cumulative impact of six abiotic factors on richness and density respectively. The rotifer communities of the different *pats* are characterized by relatively higher species diversity, lower dominance and higher evenness.

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**Table 6**: Rotifera Density, Species diversity, Dominance and Evenness

| Lakes | Density (n/l) | Mean density (n/l) | Percentage | Species Diversity | Dominance | Evenness |
|---|---|---|---|---|---|---|
| Loktak | 84-188 | 125 ±25 | 46.6 ±4.1 | 3.760 ±0.232 | 0.070 ±0.028 | 0.953 ±0.048 |
| Waithou | 87-198 | 119 ±25 | 53.5 ±3.1 | 3.507 ±0.128 | 0.069 ±0.013 | 0.946 ±0.023 |
| Utra | 65-135 | 87 ±22 | 45.9 ±4.7 | 3.375 ±0.081 | 0.075 ±0.018 | 0.943 ±0.028 |
| Sana | 70-139 | 91 ±20 | 54.5 ±3.6 | 3.007 ±0.110 | 0.092 ±0.012 | 0.902 ±0.019 |
| Lakoi | 80-167 | 102 ±27 | 57.3 ±3.3 | 2.901 ±0.079 | 0.085 ±0.021 | 0.923 ±0.026 |
| Takmu | 60-121 | 76 ±18 | 57.6 ±3.7 | 2.834 ±0.091 | 0.098 ±0.019 | 0.898 ±0.022 |
| Ikop | 63-128 | 81 ±20 | 54.4 ±3.6 | 2.891 ±0.101 | 0.112 ±0.027 | 0.879 ±0.031 |
| Kharung | 70-130 | 84 ±19 | 55.6 ±2.7 | 2.987 ±0.113 | 0.106 ±0.031 | 0.887 ±0.036 |
| Khoidum | 58-119 | 71 ±18 | 55.0 ±3.8 | 3.026 ±0.128 | 0.089 ±0.019 | 0.928 ±0.029 |
| Lousi | 60-124 | 72 ±21 | 54.5 ±3.4 | 3.020 ±0.099 | 0.092 ±0.026 | 0.929 ±0.034 |
| Karam | 65-127 | 89 ±19 | 55.2 ±3.9 | 3.103 ±0.106 | 0.095 ±0.037 | 0.903 ±0.025 |
| Ngagua | 60-110 | 70 ±16 | 58.8 ±3.5 | 3.060 ±0.098 | 0.114 ±0.022 | 0.899 ±0.030 |
| Tankha | 62-118 | 72 ±20 | 55.3 ±3.0 | 2.768 ±0.092 | 0.090 ±0.029 | 0.911 ±0.029 |
| Lamphel | 57-106 | 69 ±18 | 55.6 ±3.4 | 2.965 ±0.117 | 0.102 ±0.022 | 0.901 ±0.030 |
| Pumlen | 76-131 | 90 ±24 | 46.9 ±3.5 | 3.102 ±0.092 | 0.078 ±0.029 | 0.942 ±0.021 |

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# DISTRIBUTION, ABUNDANCE AND BIOLOGY OF PELAGIC STINGRAY *PTEROPLATYTRYGON VIOLACEA* (BONAPARTE, 1832) (MYLIOBATIFORMES, DASYATIDAE) IN THE INDIAN EEZ

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Data on the bycatch species of the Tuna longline survey voyages undertaken by the four survey vessels of Fishery Survey of India (FSI) from January 2005 to December 2007 was analysed to study the distribution, abundance and biology of the Pelagic stingray, *Pteroplatytrygon violacea* (Bonaparte 1832) in the Indian Exclusive Economic Zone (EEZ). A total of 378 specimens of the species were caught from Arabian Sea, Bay of Bengal, and Andaman and Nicobar waters during the study period. From the Arabian Sea, this species was caught at a hooking rate (HR) of 0.42 individuals/1000 hooks while a HR of 0.51 and 0.96 were registered for this species from the Bay of Bengal and Andaman and Nicobar waters respectively. The abundance was maximum in the southern latitudes (6-9° N) of Andaman and Nicobar waters. The disc width of the specimens caught was in the range of 40-62 cm, weighing 2.0-5.6 kg. The individuals belonging to the species were found to feed upon jellyfish, oceanic squids, argonauts, swarming crabs, pelagic shrimps, euphausiids and finfish. Egg bearing females were observed in the catch during December-March of every year of the study period and a single mother carrying three embryos were caught during May 2006. The present study forms the first report of this species from the Indian waters.

**Key words**: pelagic stingray, bycatch, tuna longline, Arabian Sea, Bay of Bengal, Andaman and Nicobar waters, Indian EEZ

**Abbreviations used**: OAL – Overall length, GRT – Gross Registered Tonnage, HR – Hooking Rate, TL – Total Length, DW – Disc Width, CPUE – Catch Per Unit Effort, SST- Sea Surface Temperature

## INTRODUCTION

Longline fishery targeting tunas and swordfish catches a number of other species as bycatch. The bycatch in marine fisheries is an increasingly prominent international, ecological, social and economic issue (Alverson *et al.* 1994; FAO 1999; Cook 2001; Gilman 2001; Dobrzynski *et al.* 2002; Gilman *et al.* 2005), which necessitates the importance of documentation and quantification of bycatch in different fishing methods. Species composition of the bycatch in the tuna longline fishery in the Indian Exclusive Economic Zone (EEZ) show many interesting species hitherto not reported or poorly documented in Indian EEZ. Since India is establishing itself as a major tuna fishing nation in this part of the globe by converting the loss making shrimp trawlers to tuna longliners (Somvanshi *et al.* 2008), it is the need of the hour to study more about the bycatch in the tuna fishery for effective management of these resources. In the spirit of the Code of Conduct for Responsible Fisheries, an attempt was made by the Fishery Survey of India (FSI) to explore the abundance and distribution pattern of major bycatch species of longline fishery in the Indian EEZ. Distribution and abundance of one such bycatch species, the Pelagic Stingray *Pteroplatytrygon violacea* (Bonaparte 1832) as revealed during the tuna longline survey conducted by the FSI vessels in the Indian EEZ is presented in this paper. Results of preliminary studies on the biology of this species caught from the Arabian Sea are also presented here.

The Pelagic Stingray *P. violacea* is the only currently known pelagic species of the Family Dasyatidae. Until recently, the pelagic stingray was classified under the genus *Dasyatis*, and later moved to *Pteroplatytrygon* by McEachran and Fechhelm (1998). Synonyms of this species appearing in the literature include *Trygon violacea* Bonaparte, 1832, *T. purpurea* Smith, in Muller and Henle 1841, *Dasyatis purpurea* Banard 1934, *D. atratus* Ishiyama and Okada 1955, *D. guileri* Last 1979 and *D. violacea* Bonaparte 1832. Pelagic Stingray is distributed in the tropical to temperate waters of all the major oceans (Wilson and Beckett 1970; Hart 1973; Nakaya 1982; Branstetter and McEachran 1983; Compagno 1987; Lamilla and Melendez 1989; Nishida and Nakaya 1990; Menny *et al.* 1995; Menny and Stechmann 2000; Bañón 2000; Mollet 2002; Letourneur *et al.* 2004; Domingo *et al.* 2005). In the Indian Ocean, the species has been reported from Australia (Last and Stevens 1994), Reunion Island (Letourneur *et al.* 2004) and Indonesia (White *et al.* 2006). A review of the literature shows that the occurrence of *Pteroplatytrygon violacea* is not reported so far from the

Indian EEZ. The longline survey vessels of FSI are regularly hooking this species all along the Indian EEZ. Since humans do not consume this fish, when caught onboard commercial longliners it is killed, as the fishermen fear possible stinging while removing the hook, and thrown out at the sea. Therefore, the catch is not usually reflected in the logbooks of the industrial longline operators.

## MATERIAL AND METHODS

Data gathered by the scientists participating onboard four tuna longline survey vessels of FSI during January 2005 to December 2007 are analyzed for studying the distribution, abundance and biology of pelagic stingray. The vessels, *MFV Matsya Vrushti* (OAL 37.5m, GRT 465t), and *MFV Yellow Fin* (OAL 36.0m, GRT 290t) operating from Mumbai surveyed the West coast (Arabian Sea), while the other two vessels, *MFV Matsya Drushti* (OAL 37.5m, GRT 465t) and *MFV Blue Marlin* (OAL 36.0m, GRT 290t), belonging to Chennai and Port Blair Base, surveyed the Bay of Bengal, and Andaman and Nicobar waters of the Indian EEZ, respectively. While conventional Japanese multifilament longline with five hooks per basket was operated from the vessels *MFV Yellow Fin* and *MFV Blue Marlin*, the other two vessels operated monofilament longline gear with seven hooks per basket. The longline gear consists of a series of baited hooks attached to a main line, which is suspended from buoys floating at the sea surface. Every month, these vessels are deployed for voyages of 20 days duration, and about 15 longline operations are conducted in each voyage, operating an average of 9,000 hooks. The general method of operation is: shooting of the line begins before sunrise and is completed in about 2-2.5 hours. On an average 600 hooks are operated per set. Immersion time of 5-6 hours is allowed and hauling is done in the afternoon starting from the initially shot end.

Onboard, the Pelagic Stingray *Pteroplatytrygon violacea* (Bonaparte 1832) was identified following characters described by Smith and Heemstra (1986). After the identification, all the specimens caught during the survey voyages were subjected to morphometric measurements using fish measuring board to the nearest millimetre and weighed using a digital balance with a precision of 0.01 gm. The fishes were dissected to study their sex, maturity stages, and stomach condition. The gonads and guts were preserved in well-labelled polythene bags and kept in frozen condition until they were shifted to the shore laboratory for further investigations. After the conclusion of the voyage, samples were brought ashore for attending the detailed biological studies. Standard protocols were followed for studying the reproduction and food and feeding habits, in the shore laboratory (Stillwell and Kohler 1982; Peres and Vooren 1991).

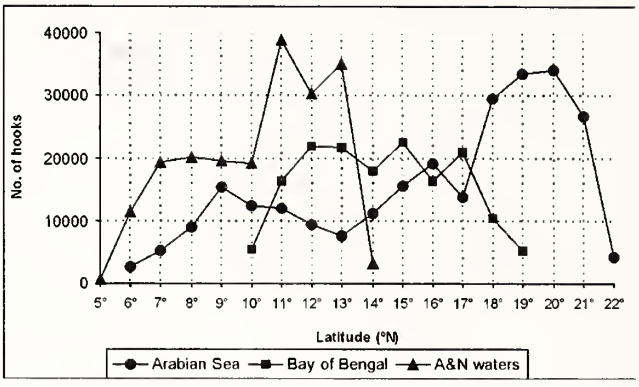


Fig. 1: Latitude-wise number of hooks operated in different regions of the Indian EEZ during the 2006-2007

For data analysis, Indian EEZ was divided into three regions, namely Arabian Sea, Bay of Bengal, and Andaman and Nicobar waters. The data gathered from January 2005 to December 2007 were treated separately for the three regions and analyzed for studying the spatial distribution, abundance and percentage contribution of Pelagic Stingray to the total catch. Abundance index is expressed in terms of Hooking rate (HR), the number of fish caught per 1,000 hooks.

## RESULTS

During the study period, the four longliners together operated 6,16,314 hooks in the Indian EEZ. Of this, 2,61,002 hooks were operated in the Arabian Sea (6°-22° N), 1,58,492 in the Bay of Bengal (10-19° N) and 1,96,820 in the Andaman and Nicobar waters (5°-14° N). Latitude-wise number of hooks operated in the three regions (Fig. 1) show that the hooks operated at each latitude ranged between 625 and 38,720.

### Morphological characters

The specimens of *P. violacea* hooked during the study were observed to have the following morphological characters. Body diamond-shaped with a broadly rounded snout and angular pectoral disc. Wedge-shaped disc slightly wider than long, convex at the front, with broadly rounded corners, and straight on the sides. Eyes small and do not protrude. Tail about twice body length with a long lower caudal finfold ending far in front of tail tip, but with no upper finfold. Tail with a thick base, tapering to the origin of the single extremely long (13.0-13.5 cm TL) and highly venomous serrated spine. Front margin of the pelvic fin straight, outer corner broadly rounded. No prominent markings on the body. Colour uniformly violet, purple, or dark blue-green dorsally, underside white.

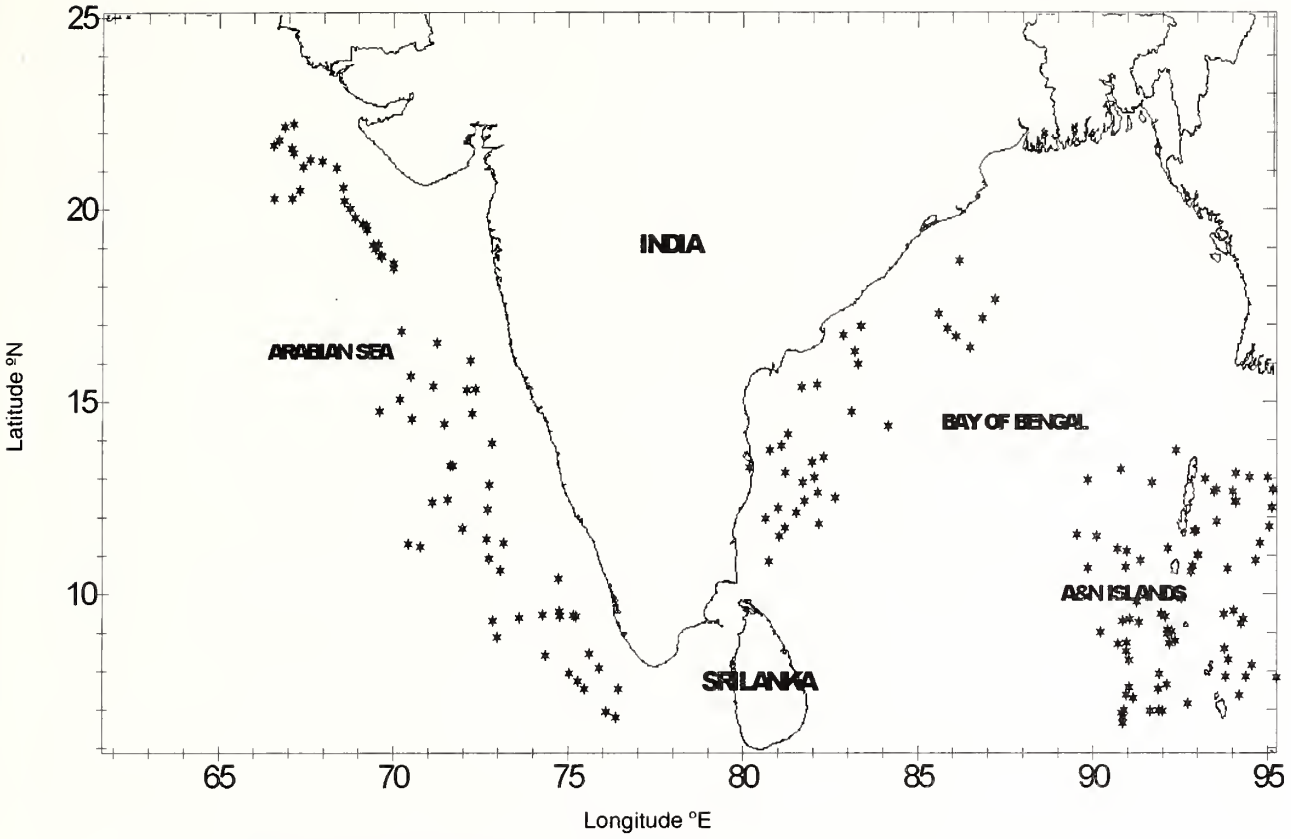


Fig. 2: Map showing the locations of hooking of *P. violacea* during the present study

**Distribution and abundance**

Total of 378 individuals of *P. violacea* were hooked during the survey period, registering a Hooking Rate (HR) of 0.613 individuals per 1,000 hooks. The Pelagic Stingray was caught from almost all the areas surveyed during the period. Sampling stations from where the species was hooked (Fig. 2) indicate wide distribution of the species. HR recorded from different latitudes and their percentage contribution to the total catch registered from these areas (Figs 3, 4, 5) did not show any remarkable trend in their abundance indices.

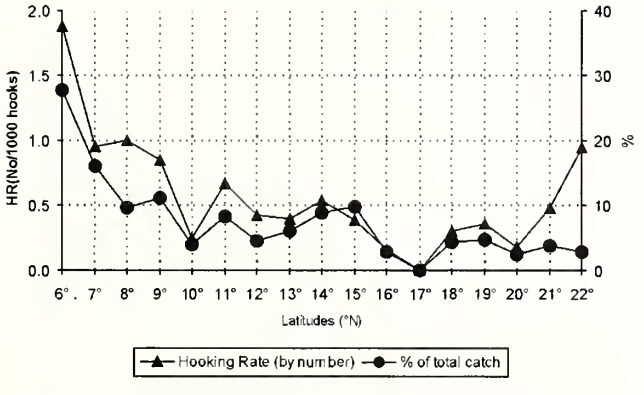


Fig. 3: Hooking rate of *P. violacea* and its percentage contribution to the total catch recorded from the Arabian Sea

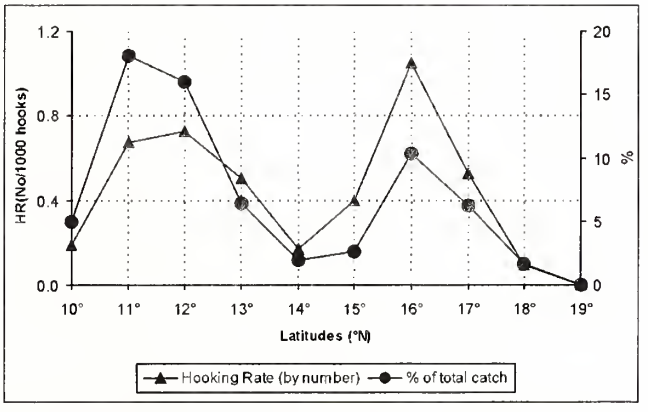


Fig. 4: Hooking rate of *P. violacea* and its percentage contribution to the total catch recorded from the Bay of Bengal

In the Arabian Sea, a total of 109 individuals of this species were hooked registering a hooking rate of 0.42 individual/1000 hooks. The percentage contribution of the species to the total catch from this area was 5.32%. Latitude-wise data shows maximum abundance in the 6° N with a HR of 1.88 followed by and 8° N (1.00) and 7° N (0.95). At 6° N, this species alone constituted 27.78% of the total catch while its contribution to the total catch from 7° N was 16.13% (Fig. 3). In northern Arabian Sea, maximum catch rate was recorded from the 22° N with a HR of 0.94. From

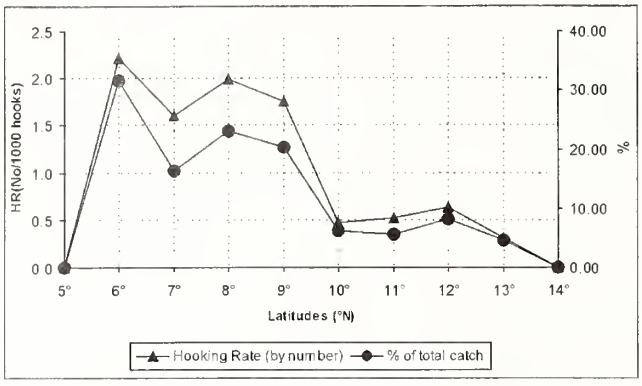


Fig. 5: Hooking rate of *P. violacea* and its percentage contribution to the total catch recorded from the Andaman & Nicobar waters

the Bay of Bengal, 80 specimens of this species were hooked during the study period, registering a HR of 0.51. Hooking rate was maximum in the 16° N (1.05), followed by 12° N (0.73) and 11° N (0.68). In the 11° N, this species constituted 18.03% of the total catch (Fig. 4). In the Andaman and Nicobar waters, *P. violacea* was more abundant in the southern latitudes, 6°-9° N. Maximum HR was recorded from the 6° N (2.21) followed by 8° N (1.99). The species contributed 31.65% to the total catch recorded from the 6° N of Andaman and Nicobar waters. Contribution of this species to the total catch from the 8° N (22.99%), 9° N (20.36%) and 7° N (16.40%) of Andaman and Nicobar waters also were significant (Fig. 5). Although limited survey was conducted in the 5° and 14° N, pelagic stingray were not hooked from these two latitudes.

**Biological observations**

The disc-width, weight and biological aspects analysed in the present study revealed that disc-width of the specimens caught ranged from 40-62 cm, while weight of the specimens ranged from 2.0 to 5.6 kg. Food and feeding studies conducted showed that this species feeds on Jellyfish, oceanic squids, *Argonauta* spp., crabs, pelagic shrimps, euphausiids and finfish. About 22% of the stomachs examined during the present study were found to be empty. Swarming crab, *Charybdis smithii* was the single dominant prey item observed in the stomach. Oceanic squid species, including *Sthenoteuthis oualaniensis*, *Onychoteuthis banksii* and *Histeoteuthis* sp. also were found to be contributing significantly to the food of Pelagic Stingray of the Indian EEZ. A variety of small pelagic fishes belonging to the families Nomidae, Myctophidae, Gempylidae, Sternoptychidae, and Carangidae were also found among the gut contents.

**Reproduction**

The sexual development in Pelagic Stingray is ovoviviparous (aplacental viviparity), i.e., producing living young from eggs that hatch within the female's body. While inside the uterus, the embryos are nourished by yolk, later they receive additional nourishment from the mother by indirect absorption of uterine fluid, which is enriched with mucous, fat or protein through specialized structure (Dulvy and Reynolds 1997). In the present study, the sex ratio of the specimens collected was 3:1 (M:F). Egg-bearing females were observed during December-March, while a single mother carrying three embryos was reported during May 2006 from the Arabian Sea. The specimen carrying the embryo had a disc-width of 58 cm weighing 4.3 kg. The colourless embryos extruded out of the mother's body had a disc-width 7.5 to 8.2 cm and the weight of embryos ranged from 16.9 to 18.3 gm. Since the gestation period of this fish is usually four months (Hemida *et al.* 2003), it is inferred that parturition will be during June-September in the Arabian Sea.

## DISCUSSION

A review of available literature showed that the Pelagic Stingray *P. violacea* is not reported and investigated, so far, from the Indian EEZ, the present study forms the first report of this species in the Indian EEZ. This fish constitutes a considerable part of the bycatch in the industrial tuna longline fishery, playing a role in the pelagic ecosystem of the world oceans. Although most of the Pelagic Stingrays hooked on longline are taken onboard in live condition, the fishermen, fearing possible stinging, usually kill the ray by banging it on the sides of the vessel before removing the hook and throwing the carcass into the sea. Ward and Myers (2005) reported that industrial fishing had resulted in shifts in open ocean fish communities reducing the abundance (by 21%) and biomass (by a factor of 10) of tunas and sharks in the tropical Pacific Ocean. However, the population of several small and formerly rare species, like Pelagic Stingray had increased. Environmental parameter like Sea Surface Temperature (SST) is reported to have some influence on the distribution of *P. violacea*. Domingo *et al.* (2005) reported increase in the CPUE of *P. violacea* with Sea Surface Temperature in Uruguayan waters. Higher catch rate was registered when SST recorded >20°C. During the present study, no attempts were made to correlate the abundance with SST. Low fecundity (1 to 9 per litter) of this fish makes the species more vulnerable to over exploitation. Based on the mathematical models suggested by Musick (1999), Froese and Pauly (2005) had categorized this fish as having "very low resilience" (minimum population doubling time more than 14 years (K=0.18 (captivity); Fec=1-9), while the species is categorised as with "High to very high vulnerability"

(66 of 100) based on the model suggested by Cheung *et al.* (2007). These peculiar life history traits of the species warrant a cautious approach for the management of this species in the pelagic ecosystem. Mitigation devices for reducing the number of Pelagic Stingray hooked in the longline also need to be developed for avoiding possible stock depletion due to longline fishing. Mitigation devices will help the fishermen, who consider the Pelagic Stingray as a pest consuming the bait aimed for highly valued tunas and swordfish. More studies on bycatch are needed to account the impact of longline fisheries on species associated with or dependent upon harvested species with a view to maintaining or restoring populations of such associated or dependent species above the levels at which their reproduction and recruitment may become seriously threatened.

## ACKNOWLEDGEMENTS

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# STATUS AND DISTRIBUTION OF HANGUL *CERVUS ELAPHUS HANGLU* WAGNER IN KASHMIR, INDIA

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Hangul (*Cervus elaphus hanglu*) is an endangered cervid restricted to the Kashmir valley. At present, a demographically viable population of Hangul occurs only in Dachigam National Park. Between March 04 and 06, 2004, the Hangul population estimation exercise was carried out at a landscape level in central and southern divisions of Kashmir valley. Two hundred and ninety-six observers were trained in February 2004 for this exercise; in the Central division 175 observers walked 964 km, and in the South division 121 observers walked 2,014 km for data collection. In the Central division, Hangul population was estimated to be 214 (SE = 29). Density was estimated to be 3.09 hangul/sq. km (SE = 0.66). In the South division, the minimum Hangul population estimate was 30. The fawn ratio was observed to be 21 fawns/100 hinds, and sex ratio was 20 stags/100 hinds. The decline in hangul population can be reversed by controlling factors responsible for fawn mortality, grazing pressure/disturbance in the habitat, control of pariah/domestic dog population and discontinuing the release of problem leopards in the area. There is an urgent requirement to initiate a conservation breeding programme to augment Hangul population in the wild.

**Key words**: Hangul population, Line Transect, Lincoln-Peterson, Bounded-Count, sex ratio, Fawn Ratio, monitoring

## INTRODUCTION

India has witnessed unprecedented loss of species due to human action in recent times. Conservation efforts in India intensified in the 1970s to safeguard species and habitats. The lack in implementation of scientific monitoring programme to track the population response under rapidly changing scenarios has left no information to take corrective measures in time. Hangul (*Cervus elaphus hanglu*) amongst many other endangered species like Barasingha (*Rucervus duvauceli*), Tiger (*Panthera tigris*), Gharial (*Gavialis gangeticus*), Vulture (*Gyps* sp.), and Great Indian Bustard (*Ardeotis nigriceps*) are facing problem due to lack of response to detrimental factors in appropriate time.

The endangered Hangul's range in Kashmir lies between Zanskar and Pir-Panjal mountain ranges. The other subspecies of Red Deer *Cervus elaphus wallichi* (*Shou*), which used to occur in the mountains of East Sikkim, is now extinct. Hangul assumes great significance as the only survivor of Red Deer in the Indian subcontinent. Historically, Hangul range was restricted to an arc of 65 km in width; north and east of Jhelum, and lower Chenab river, from Shalurah in the north to Ramnagar in the south (Lydekker 1924; Holloway 1970). A small population existed outside Jammu and Kashmir in the Chamba district of Himachal Pradesh (Lydekker 1924), which is now extinct. In the recent past, Hangul population has declined considerably in their existing distribution range. The present situation can be attributed to a large scale biotic interference, habitat fragmentation and degradation. In its present range, a demographically viable population of Hangul occurs only in Dachigam National Park.

There is a need to adopt robust sampling methods to establish the trends in the Hangul population. The total count of Hangul had been attempted by the Wildlife Protection Department (Jammu & Kashmir) with the right intention, but it failed to provide meaningful trends. Monitoring programme for species should be based on appropriate scientific design, inclusive of detection probabilities for individuals (Pollock *et al.* 2002). Usually data is gathered with a vague hope that somehow it will prove useful for conservation; instead it should be focused on precise information needed (Nichols and Williams 2006). We initiated a population estimation programme at landscape level to evaluate current status, and thereby design an effective monitoring protocol.

## STUDY AREA

The Hangul population estimation was mainly done in the landscape of central and southern divisions of Kashmir valley, encompassing an area of approximately 808 sq. km. These divisions include ten conservation reserves, three

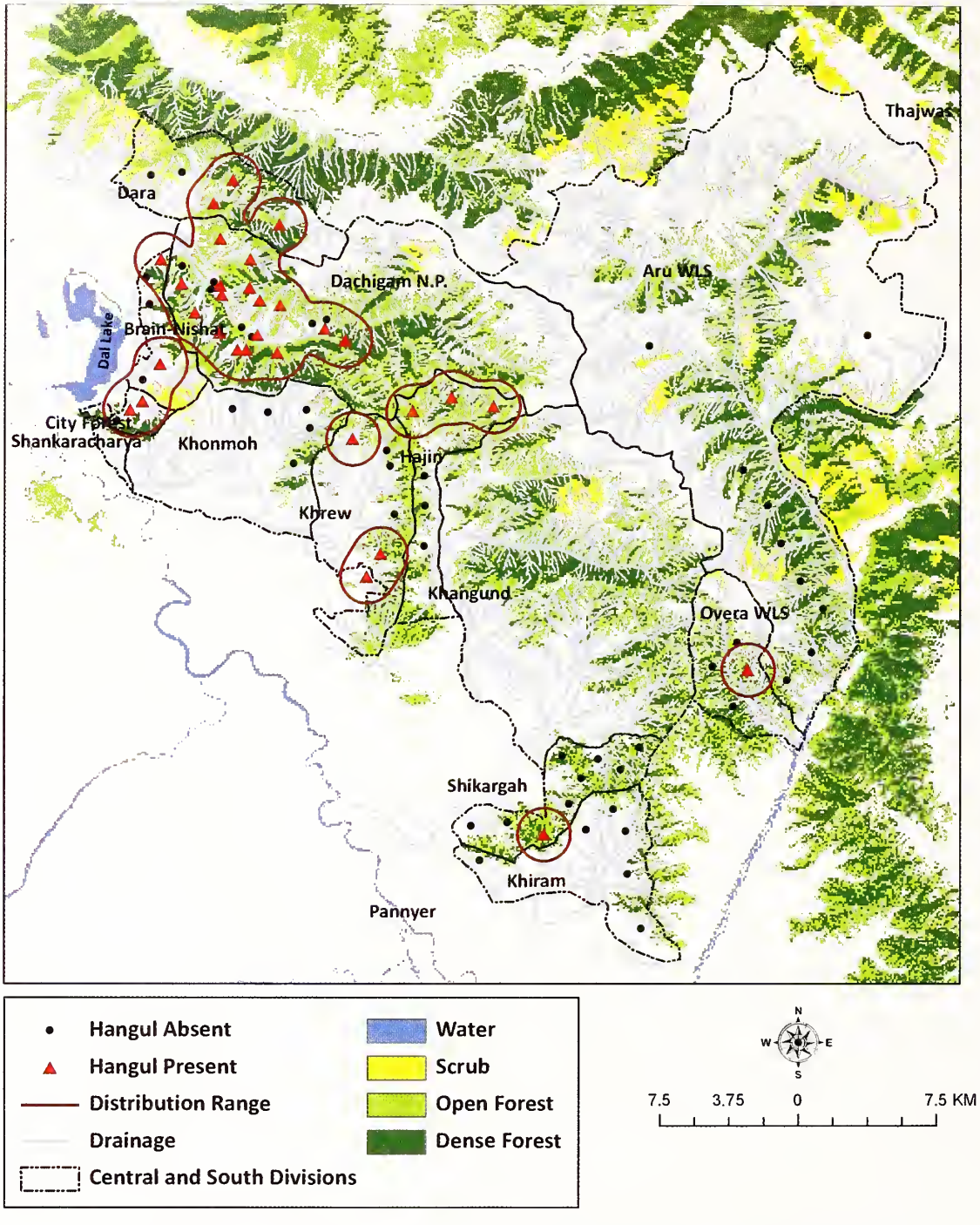


Fig. 1: Hangul distribution and area surveyed (2004) in Central and South divisons of Jammu and Kashmir

wildlife sanctuaries (Daksum, Overa-Aru and Thajwas), and Dachigam (lower) National Park (Table 1, Fig. 1).

Hangul is distributed between an elevation of 1,700 m to 3,500 m. This area harbours broad leaf mesophyll forest of Maple (*Acer* sp.), Mulberry (*Morus alba*), *Ulmus* spp., *Rhus* spp., Walnut (*Juglans regia*), *Hatab* (*Parrotiopsis jacquemontiana*), a variety of conifers such as Deodar (*Cedrus deodara*), Blue pine (*Pinus wallichiana*), Spruce (*Picea smithiana*), and Fir (*Abies pendrow*) (Singh and Kachroo 1987; Bano *et al.* 1995; Ahmad *et al.* 2002). The riverine vegetation below 2,300 m elevation is dominated by broad-leaved forest. The major shrub comprise of *Viburnum cotinifolium*, *Berberis lycium* and *Parrotiopsis jacquemontiana* (Singh and Kachroo 1987; Bano *et al.* 1995).

The higher reaches (above 3,300 m) comprise of scrub vegetation of Birch (*Betula utilis*) and *Rhododendron* spp. interspersed with meadows (Bano *et al.* 1995), followed by a permanent snow line, which is above 3,500 m (Rodgers and Panwar 1988).

## METHOD

The population estimation exercise was systematically carried out in 1960s. Gee (1965) had guestimated the population size in 1957 and 1965. Schaller (1969) estimated Hangul population during the rut and concluded that rutting period is not good for population estimation. Holloway (1971) conducted a count in November 1969 and February 1970. He divided the area into six blocks; each block was scanned by a group of individuals so as to maximize the detection. The Jammu and Kashmir Wildlife Department followed Holloway's method for Hangul counts. The census method of Wildlife Protection Department was more or less consistent and enumeration was done largely in mornings except in a few cases when it was conducted both in the morning and evening (Department of Wildlife Protection 1996, 1997, 2000, 2001, 2002, 2003).

The present hangul population estimation exercise was carried out in the Central and South division of Kashmir valley. February 2004 was the training period and actual count exercise was conducted between March 04 to 06, 2004 (Table 1, Fig. 1). On March 13, Hangul sex ratio exercise was conducted. This exercise for population estimation has been modified by adapting the transect method. In all, 296 forest staff and volunteers were trained for a period of two weeks during February 2004 in transect marking and data collection. The data collected includes ocular sighting distance, hangul group sizes, age and sex, habitat type and other animal species of interest.

**Table 1**: Landscape covered for population estimation exercise

| Area | sq. km |
|---|---|
| Brain-Nishat | 15.75 |
| City Forest | 9.00 |
| Khrew | 50.25 |
| Khonmoh | 67.00 |
| Dara | 34.00 |
| Hajin | 22.08 |
| Khangund | 15.00 |
| Shikargah | 15.5 |
| Pannyer | 10.00 |
| Khiram | 15.75 |
| Overa-Aru Wildlife Sanctuary | 378.13 |
| Thajwas Wildlife Sanctuary | 55.5 |
| Rajparian Wildlife Sanctuary | 20 |
| Dachigam (lower) National Park | 100.36 |
| Total Area | 808.32 |

In Central Division, a total of 49 transects were marked and data was collected by 175 forest staff/volunteers walking 964 km and investing 864 hours in search effort (Fig. 1). In South Division, a total of 40 transects were identified and marked where 121 staff members walked 2,014 km and invested 890 hours to collect data (Fig. 1).

### Analysis

Hangul abundance was estimated by four analytical methods, (a) density estimate based on Hayne's estimator, (b) encounter rates based on length walked and time spent in search (c) Bounded count and (d) Lincoln-Peterson estimate.

a) **Hayne's Estimator**: The transect data was analyzed for estimating abundance, based on angular distance (Hayne 1949; Eberhardt 1978; Gates 1979; Laake *et al.* 1993). The angular distance gives an idea about the visibility of animal in a given habitat (Hayne 1949; Gates 1979; Burnham *et al.* 1980; Lancia *et al.* 1994). The estimator for group density is

$$Dgrp = \left( \left( \frac{n}{2L} \right) * \left( \frac{1}{n} \right) * \Sigma \left( \frac{1}{ri} \right) \right)$$

where Dgrp = Group density, n = number of groups, L = Total Transect Length and ri = Angular distance of each sighting.

The variance was estimated using Delta Method (Seber 1982) as

$$VarDgrp = (Dgrp)^2 * \left( CV \left( \frac{n}{l} \right) \right)^2 * \left( CV \left( \frac{1}{ri} \right) \right)^2$$

where CV = coefficient of variation, n/l = encounter rate per transect and 1/ri = harmonic mean of angular distances.

The density of individuals (Dind) was estimated by,
Dind = (Dgrp * Xgrp),
where Xgrp = Mean Group Size and
variance of individual density is estimated as

$$VarDind = (Dind)^2 * \left( CV \left( \frac{n}{l} \right) \right)^2 * \left( CV \left( \frac{1}{ri} \right) \right)^2 * (CV\ grp)^2$$

where CVgrp = CV of Group Size

The Hayne's estimator based density should be treated as an index of abundance and will be an useful estimate particularly in absence of equipment like compass and range finder.

b) **Encounter Rate** was estimated by transect length

(number of hangul on each transect / transect length) and search time (number of hangul on each transect / search time on each transect).

c) **Bounded-count Method**: Here it is assumed that all animals could be counted without duplication during a survey of the population and that the process can be independently repeated. Regier and Robson (1967) proposed a Bounded-count Method which is based on the Jackknife Method of Quenouille (1956). The abundance estimator is based on the theory of estimating a truncation point by Robson and Whitlock (1964). Letting $\tilde{N}$ denote the true abundance and *m* the number of times the population is assessed, the bounded-count estimator is

$\tilde{N} = 2\, x_m - x_{m-1}$

where,

$\tilde{N}$ = Population Estimate

$x_m$ = largest of the *m* counts obtained;

$x_{m-1}$ = second largest count obtained.

An approximate confidence interval for population estimate $\tilde{N}$ with lower limit being $x_m$ (the largest count) and upper limit by:

$= 1/\alpha\,(x_m - (1-\alpha) - x_{m-1})$, where $\alpha$ (significance level) we used was 0.1 (90%).

The assumptions of the Bounded-count Method include, probability of detection should be sufficiently high. The *m* counts are independent, probability of detection is constant across all replicate, animals are not counted more than once and population is closed during the course of the surveys (Overton 1969).

d) **Lincoln-Peterson Estimate**: The problem of estimating the size of a population from "total counts" known to be inaccurate has been approached from several directions. The binomial count disparate or multiple are applicable when the entities being counted cannot be distinguished individually, but each of these methods suffer from the requirement that the population is counted, *albeit* incompletely, on numerous occasions (Caughley 1974; Magnusson *et al.* 1978; Young and Peace 1999; Williams *et al.* 2001; MacKenzie *et al.* 2002; Royle and Dorazio 2008). Chapman's (1951) modified Lincoln-Peterson Estimator was used to calculate the abundance of groups;

$$Ngrp = \frac{(S1+1) * (S2+1)}{(B+1)} - 1$$

and its Variance is estimated by

$$Var\ Ngrp = \frac{(S+1)*(S2+1) * (S1-B) * (S2-B)}{(B+1)\text{^}2 * (B+2)}$$

where, S1 and S2 are number of group types (1,4,8,12,16 and >22) seen on each transect in 1st and 2nd survey, and B group types common to both survey (Pollock *et al.* 1990; Young and Peace 1999; Chao *et al.* 2001).

The number of individuals (Nind) was estimated by,

Nind = Ngrp * Xgrp,

where, Xgrp is Mean Group Size

Population variance was estimated by Delta Method (Seber 1982) using variance of group estimate and group size,

$$VarNind = (Nind)^2 * (CV\ Ngrp)^2 * (CVgrp)^2$$

where VarNind=Variance of population estimate, CV Ngrp = CV of Number of Groups in Population, and CVgrp = CV of Group sizes Observed.

The population was closed in terms of death, predation, birth, emigration and immigration, and individuals are equally likely to be sighted in different surveys.

The use of Lincoln-Peterson and Bounded-count Method assumes that the two counts are independent and that there is constant probability of seeing each group by a given method of survey. Clearly, such a sampling frame exists only conceptually for wildlife populations (Bowden *et al.* 1984). Alternatively, cluster sampling uses groups as the sampling unit (Bowden *et al.* 1984), because many species, especially ungulates, are typically observed in social groups. The assumption that groups are selected with equal probability (Bowden *et al.* 1984) is unreasonable in many cases because of visibility bias. More appropriately, we can estimate the probability of observing groups of animals by developing models of visibility bias.

The reliability of sight-resight estimate in this condition needs to address two crucial aspects, i.e., (i) the detection of group sizes are proportional in all surveys to evaluate aggregation or splitting of groups, thus group size categories used for estimation were compared across three counts using Fishers Exact Test and (ii) the average detection distance, i.e., visibility and effort is similar in surveys, detection distances were compared using Kruskal-Wallis ANOVA. This method is used in this case considering the area sampled remains same and group sizes used as an identity do not differ significantly across surveys, if groups are very fluid this method cannot be applied.

Statistical analysis was done using R 2.5. (R Foundation for Statistical Computing, 2007), S plus 4.5 (Lucent Technology Inc.), Excel (Microsoft Inc.) and Care 1 (Chao *et al.* 2001).

**Hangul Distribution**

All transects were mapped with the help of a Global

Positioning System (Garmin©).

Minimum Convex Polygon and Kernel methods were used for Hangul distribution (Animal Movement extension in ARC GIS9.1, ESRI INC). The area from Kernel Method was used as effective area occupied by Hangul.

## RESULTS

**Hangul Population Estimate**:

A three-day population estimate and transect-based density estimate was only possible for the Central division as the South division had very few Hangul sightings (Tables 2 and 4). The group sizes were proportionally similar (P=0.95) across three surveys and there was no difference in detection distance of groups (P=0.24) among these surveys, thus satisfying our assumptions for use of Bounded-count and Lincoln-Peterson analysis, i.e., group sizes do not change and there is no detection bias.

### Central Division

The mean count for three days was 213 (±25) (Table 2). The Bounded-count based estimate was 247 (Table 3). Three Lincoln-Peterson estimates for hangul group abundance ranged from 25 to 33 (Table 3). The mean population estimate was 214 (Table 3). The best hangul sighting in Dachigam National Park was in Reshwadri followed by Draphama, Drog, Manyu, Kaunar and Badin nalla.

**Hangul Density and Encounter Rate**: Hangul group density was 0.43 hangul group/sq. km (SE=0.07) and density of individuals was 3.09 hangul / sq. km (SE=0.66, CV=22%).

Transects in Mulnar, Drog, Reshwadri, Oak patch to Draphama area had the highest encounter rate of 1.79 hangul/km. The hangul encounter rates in areas surrounding Dachigam were 0.23/km in Nishat, 0.11/km in Khrew and 0.08/km in Dara. Hangul was not sighted in the Khonmoh sector, though indirect evidences were observed.

The other species seen on transects in Central Division were Musk Deer (*Moschus chrysogaster*), Langur (*Semnopithecus entellus*), Rhesus Macaque (*Macaca mulatta*), Black Bear (*Ursus thibetanus*), Leopard (*Panthera pardus*), Jackal (*Canis aureus*), Fox (*Vulpes bengalensis*), Yellow-throated Martin (*Martes flavigula*), Porcupine (*Hystrix indica*), Chakor (*Alectoris chukar*), Koklas (*Pucrasia macrolopha*) and Monal (*Lophophorus impejanus*).

### South Division

In South Division, analysis of population estimation was not possible as data set was too small. The maximum count of 30 was taken as minimum population of Hangul in this division (Table 4).

Encounter rate of Hangul in this Division was very poor as compared to the Central Division. In South Division, Shikargah had the highest mean encounter rate 0.14 hangul/km followed by Khangund 0.04 hangul/km and Overa 0.02 hangul/km. Indirect signs of Hangul presence were observed in Pannyer Conservation Reserve. The areas that need validation for Hangul occurrence are Khiram Conservation Reserve and Daksum Wildlife Sanctuary.

The intensive surveys indicated presence of Musk Deer, Langur, Rhesus Macaque, Black Bear, Leopard, Jackal, Jungle Cat (*Felis chaus*), Fox, Koklas, Monal and Chakur. Four Wolves (*Canis lupus*) were sighted in Nanphran nalla

**Table 2**: Hangul population based on three-day sample counts (March 2004) in Central Division (Dachigam and its surrounds)

| Locality | 4th March | 5th March | 6th March | Mean | SE |
|---|---|---|---|---|---|
| 1. West Boundary-Draphama (South) | 24 | 33 | 27 | 28 | 2.64 |
| 2. Draphama-Pahlipora (South) | 12 | 41 | 29 | 34 | 3.72 |
| 3. Namblan (South) | 5 | 14 | 2 | 17 | 6.02 |
| 4. West Boundary Draphama (North) | 84 | 87 | 79 | 83 | 2.34 |
| 5. Draphama to Pahlipora (North) | 31 | 31 | 35 | 32 | 1.34 |
| 6. Pahlipora to Washkhar (North) | 0 | 0 | 0 | 0 | 0 |
| 7. Nishat to Cheshmashahi | 7 | 14 | 13 | 11 | 2.19 |
| 8. Khonmoh | 0 | 0 | 0 | 0 | 0 |
| 9. Khrew | 12 | 0 | 0 | 4 | 4.01 |
| 10. Dara | 4 | 0 | 8 | 4 | 2.31 |
| Total | 179 | 220 | 193 | 213 | 24.57 |

**Table 3**: Population estimate of Hangul based on Bounded-count and sight-resight estimator (Chapman modified) in Central Division ( March 4-6)

| Survey Dates | Group Estimates | CI-L | CI-U | SE | CV (%) |
|---|---|---|---|---|---|
| pair(4,5) | 25 | 25 | 29 | 1 | 4 |
| pair(4,6) | 29 | 28 | 33 | 1 | 3 |
| pair(5,6) | 33 | 32 | 41 | 2 | 6 |
| | Individual Estimate | | | | |
| pair(4,5) | 184 | 138 | 230 | 23 | 13 |
| pair(4,6) | 214 | 163 | 265 | 26 | 12 |
| pair(5,6) | 243 | 173 | 314 | 36 | 15 |
| Bounded-count | 247 | 243 | 261 | | |

Abbreviations: 90% CI-L - Confidence Interval Lower, CI-U - Confidence Interval Upper and CV - Coefficient of Variation

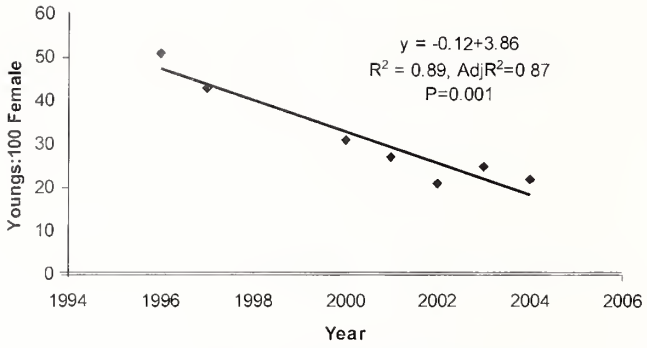


Fig. 2: The decline in Hangul young: hind ratio between 1996 to 2004

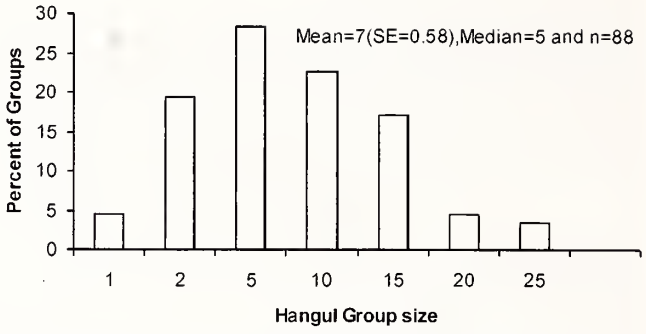


Fig. 3: Hangul Group size distribution in Dachigam (Central Division) present study

(Lidder-Aru) and a Snow Leopard (*Uncia uncia*) track was recorded in Sattragi (Lidder-Overa) on March 05, 2004.

The Hangul population estimate based on extrapolation of density on an area occupied in the Central and South divisions was 260 individuals.

**Hangul sex ratio and young: hind ratio**

Hangul sex ratio was estimated to be 18 stags/100 hinds (SE=1.73) (Table 5). On March 13, observers equipped with binoculars estimated sex ratio as 20 stags/100 hinds. The four days mean was 19 stags/100 hinds (SE=1.33, Table 5). The fawn ratio was 21 fawns/100 hinds. Declining trends have been observed in the Hangul fawn:hind ratio since 1996 (b=-0.12, P=0.001, Fig. 2).

## GROUP COMPOSITION

In this exercise a total of 88 Hangul groups were sighted ranging from 1 to 25. The solitary hangul sightings were 4.5% and maximum sightings (28.4%) were in groups of 3-5 individuals (Fig. 3). Mean hangul group size was 7 (SE=0.58) and the median was 5.

**Table 4**: Hangul sighted in South Division from March, 4-6, 2004

| Block | Locality and Transect Number | (4th) | (5th) | (6th) |
|---|---|---|---|---|
| Khangund | Dangnar to Serwan (Satura B) | 0 | 1 | 2 |
| | Kandernar, Aripal & Saturbal (Satura A) | 0 | 2 | 0 |
| | Aripal nallah – Brain nar | 1 | 0 | 0 |
| Shikargah | Pinglish, Haput nadji, Nagware nar | 15 | 0 | 5 |
| | Brain nar- Haputnar | 6 | 5 | 0 |
| | Tsersangnar to Goggidar | 6 | 0 | 0 |
| | Gungwan area | 0 | 2 | 0 |
| Overa-Aru | Gumri upto Rewas | 2 | 0 | 0 |
| Total | | 30 | 10 | 7 |

**Present Hangul Distribution**

At present, Hangul is largely restricted to approximately 504 sq. km of Kashmir valley in South and Central divisions; there is no report of its existence outside Jammu & Kashmir (Fig. 1). The effective area occupied by hangul in winter was 148 sq. km (Fig. 1), of which 84 sq. km was in Dachigam, 52 sq. km in areas surrounding Dachigam in Central Division and remaining 13 sq. km in South Division. The survey and interviews suggest that a few hanguls do continue to remain outside Dachigam all year round in areas of Gurez, Ajas, Bunakot, Bandipora, Kangan, Surpharo Baltal, Harmukh and Wangath. Reconnaissance surveys and interviews conducted in Upper Dachigam (Leech top to Gunus nar) and Sindh Forests suggest the presence of Hangul (Mr. Gh. Mohidin pers. comm.). In the North Division, Changdaji has a good habitat with reports of Hangul presence. These reports need to be further confirmed through systematic intensive surveys.

## DISCUSSION

Hangul was once distributed widely in the mountains and valleys of Kashmir (Schaller 1969). The only Hangul report outside Jammu & Kashmir was from Gamagul Siya-Behi Sanctuary in Himachal Pradesh (Kurt 1978). Holloway (1970) mentions its distribution to be confined to an area of *c.* 65 km in width to the North and East of Jhelum and lower Chenab rivers, from Shalurah in North to Ramnagar in South. Unconfirmed reports of isolated small populations do occur within the aforesaid range, particularly in the North (Kurt 1978). They were also known to be present in the upper Bringi valley (Holloway 1971) in Bandipora, Gurez, Sindh valley, Drass valley, Lidder valley and Desu (South-east of Srinagar) (Kurt 1978). At present, Hangul is largely restricted to *c.* 504 sq. km of Kashmir valley in South and Central

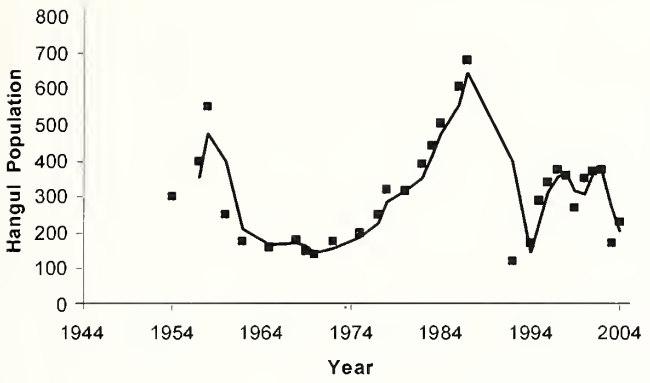


Fig. 4: Population trend in Dachigam and adjoining areas from 1954 to 2004

divisions; there is no report of its existence outside Jammu & Kashmir (Fig. 1). The range size has been reduced in comparison to Kurt's (1978) distribution map.

Hangul adult sex ratio was reported to be 151 stags/100 hinds during rut (Schaller 1969) and in non-rutting period it ranged from 15 to 25 stags/100 hinds (Holloway 1970,1971; Department of Wildlife Protection 1996, 1997, 2000, 2001, 2002, 2003) (Table 6). The Hangul sex ratio differs in different seasons due to differential habitat use by both sexes. Clutton-Brock *et al.* (1982) reported sexual segregation in Red Deer during winter. The adult sex ratio in Red Deer reportedly ranges from 50 to 70 stags per 100 hinds (Whitehead 1972; Clutton-Brock *et al.* 1982; Bonenfant *et al.* 2004). The sex ratio estimates of February-March 2004, which include all age classes, are low, but seem to be stable over the years (Table 5). The sex ratio data may be biased, but is consistent and thus difficult to provide the reasons of low ratio in comparison to Red Deer elsewhere in the world.

The young to hind ratio were estimated considering all hind age classes due to difficulty in identifying reproductive age class of hind. The young:hind ratio in Hangul was reported to range between 21 to 51 young/100 hinds during February and March (Department of Wildlife Protection 1996, 1997, 2000, 2001, 2002, 2003 and this study (2004). Schaller (1969) reported 45 juveniles/100 hinds. The counts from 2000 to 2004 indicate a decreasing trend (Department of Wildlife Protection 1996, 1997, 2000, 2001, 2002 and 2003) (Table 6, Fig. 4). The studies on Red Deer indicate fawn:hind ratio to range from 16 to 54 per 100 adult hinds, more than 30 is considered to be a good ratio (Clutton-Brock *et al.* 1982; Houston 1982; Boyce 1989). The observed trends (21 Juveniles/100 hinds) in fawn:hind ratio in Dachigam are alarming, and need careful monitoring and management. Establishing reasons for declining fawn:hind ratio is crucial.

Gee (1965) guestimated the population to be 400 in 1954, which raised alarm for the plight of Hangul. Holloway (1971) conducted a systematic count in 1969 and 1970. The population estimate of Hangul had shown an increasing trend since the 1970s and by 1987 there were 700 Hangul. After a gap of six years (1994), the population estimate was 120 (Fig. 4), the reason of this decline is not well understood, may be earlier estimates were wrong, or poaching and anthropogenic disturbances may have taken the toll. The population steadily grew to 375 individuals by 2002, which again declined to 212 in 2003 (Department of Wildlife Protection records). The total estimate in 2004 was 244 Hangul, 214 in Central and 30 individuals in South division. The extrapolation of density estimate on area occupied in South and Central divisions gave an estimate of 260 Hangul (Fig. 1). The population trend indicate decline of 5 percent /annum. There is an urgent need to establish captive breeding facility for long term conservation similar to the process done in Kanha for the Barasingha (Panwar 1978).

**Table 5**: Hangul Sex Ratio & Hind Young Ratio (March 4-6, March 13, 2004) in Dachigam and adjoining areas

| Date | Stags : 100 Hinds | Young : 100 Hinds |
|---|---|---|
| 4th Mar. 2004 | 21 | 18 |
| 5th Mar. 2004 | 18 | 28 |
| 6th Mar. 2004 | 15 | 24 |
| 13th Mar. 2004 | 20 | 15 |
| Mean | 19 | 21 |
| Standard Error | 1.32 | 2.93 |

**Table 6**: Sex Ratio and Young : Hind ratio of Hangul in Dachigam and adjoining areas

| Year | Month | Stag: 100 Hinds | Young: 100 Hinds | Reference |
|---|---|---|---|---|
| 1969 | October | 151 | 45 | Schaller 1969 |
| 1970 | February | 25 | - | Holloway 1971 |
| 1987 | March | 25 | 17 | Inayatullah 1987 |
| 1996 | February | 15 | 51 | Deptt. of Wildlife Protection,1996 |
| 1997 | February | 16 | 43 | Deptt. of Wildlife Protection, 1997 |
| 2000 | March | 18 | 31 | Deptt. of Wildlife Protection,2000 |
| 2001 | March | 21 | 27 | Deptt. of Wildlife Protection,2001 |
| 2002 | March | 22 | 21 | Deptt. of Wildlife Protection,2002 |
| 2003 | February | 18 | 25 | Deptt. of Wildlife Protection,2003 |
| **2004** | ***1 3rd-6th March** | **19** | **21** | **Present study** |

*1: Mean based on estimates done on 4th, 5th and 6th March 2004

Hangul population had been affected by diseases like Johne's disease (Kurt 1978), Foot and Mouth (Stockley 1936), Rinderpest, Anthrax, Tuberculosis, Malignant Catarhal fever and Brucellosis in Dachigam (Mir Mansoor pers. comm.). Foot and Mouth disease had taken toll of livestock and Hangul in the past (Stockley 1936).

Iqbal *et al.* (2005) reported 25 per cent Hangul occurrence in Leopard scats, which has contributed 61 per cent of prey biomass consumed by Leopard. This indicates substantial Leopard dependence on Hangul. There is a possibility of predation by other carnivores too, like pariah dogs, shepherd's dogs, jackals, black bear and other carnivores. Ward (1921) and Stockley (1936) have reported leopards taking significant number of Hangul stag and hinds. Stockley (1936) has described black bears 'as destroyer of new born calves/fawns' though Kurt (1978) has not seen predation of Hangul fawns by black bear. There are many missing ecological linkages in the understanding of the Hangul population, which need to be addressed.

Dachigam and other parts of Hangul distribution range were historically exposed to heavy anthropogenic pressure. Ward (1925), Stockley (1936), Gee (1965), Schaller (1969), Holloway (1971), Kurt (1978) and Inayat Ullah (1985) described in detail, the detrimental effects of grazing in upper Dachigam, poaching, affect of sheep breeding farm, disease, dogs of shepherds, excessive traffic in the Park and natural resource extraction by locals. After almost 88 years since these detrimental factors were first documented, most of them continue even today to affect Hangul survival and there is an urgent need to address these problems.

The population and distribution range of Hangul is getting impacted by change in habitat quality, low recruitment, predation pressure and anthropogenic pressure. It's important to monitor and evaluate factors responsible for decline in Hangul population. The adjoining areas of Dachigam National Park, Dara Conservation Reserve, Nishat Brain Conservation Reserve, Khrew and Khonmoh are facing heavy biotic interference due to developmental activities. It is recommended to have operational *chowkis* during summer, particularly in areas where Hangul and livestock overlap in habitat use. Protection, landscape level population management, and conservation breeding programme is imperative for long term hangul conservation in Kashmir.

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# NATURAL HISTORY OBSERVATIONS OF THE FOUR-HORNED ANTELOPE *TETRACERUS QUADRICORNIS*

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The Four-horned Antelope is endemic to the Indian subcontinent and is defined as data deficient by IUCN. It is found mainly in forest habitats and is usually solitary. A four-year long study was conducted on the species in Panna National Park, Madhya Pradesh, during which behavioural observations were made using opportunistic focal sampling, mapping and monitoring middens, and cafeteria experiments. A total of 2,902 minutes of cumulative observations of the Four-horned Antelope were made in the field, including 352 events when anti-predatory behaviour was recorded. It was found that the species had a preference for browsing over grazing. It was found using closed canopy thickets, with dense undergrowth or grass cover, for resting unlike Chinkara, which is a sympatric antelope of the same size. The behavioural observations were restricted to the more obvious behaviours, but provided us with a good opportunity to document these for the first time. These include mating, inter and intra-specific interactions, and anti-predatory behaviour. Data on midden locations and their usage over time were also collected to understand the stimulus behind defecation by adults and young ones on middens. It was found that while the Four-horned antelope has a peculiar anti-predatory behaviour where it prefers to hide than run, making it conspicuous and this possibly affected its choice of habitat. The middens were found to be randomly placed in space and their usage pattern indicated that they were used as points of communication between conspecifics of different age and sex groups.

**Key words**: Four-horned antelope, behaviour, Panna National Park, tropical dry deciduous forest, middens, anti-predatory behaviour

## INTRODUCTION

Studying the behaviour of animals in the wild provides useful inputs for their management (Leuthold 1977; Kilgo *et al.* 1998). The pattern of usage of habitats by animals differs greatly with activity. For many species of animals, the behaviour changes to a great extent with different levels of anthropogenic pressure (Kilgo *et al.* 1998; Bolhuis and Giraldeau 2005; Rabin 2003). While almost all census methodologies rely on some basic understanding of animal behaviour, the reaction of animals to environmental conditions, degree of adaptability to different circumstances, and conflict with humans can be best understood by gaining an in-depth knowledge of their behaviour. Behavioural traits of living species provide useful information about their evolution (Janis 1981, 1990), and about other closely related or sympatric species that have gone extinct. Behavioural ecology also provides an insight into a species' relationship with other ecological and evolutionary features, such as morphology, grouping tendencies and niche occupancy.

The Four-horned Antelope *Tetracerus quadricornis* is endemic to the Indian subcontinent, being found only in India and a few pockets of Nepal. Due to its preference for forested and undulating terrain (Prater 1980) and solitary living, it is considered one of the most elusive antelopes in India. It was considered data deficient by IUCN (Rahmani 2001) as there was little information available about its behaviour and ecology other than some observations made by Berwick (1974) in Gir, and by Bhaskaran (1999) and Kannan (1999) in Mudumalai. Apart from these studies, there were only a few historic records that discuss the distribution and behaviour of the Four-horned Antelope in greater detail (Jerdon 1867; Blanford 1888-1891; Brander 1923; Prater 1980).

The Four-horned Antelope differs in behaviour and habitat preference from the other five antelope species found in India. It is found predominantly in forest habitats, whereas the Nilgai *Boselaphus tragocalemus* uses forested and open habitats alike. The Chinkara *Gazella bennettii* and Blackbuck *Antilope cervicapra* are restricted to open habitats (Schaller 1967; Ranjitsinh 1982; Rahmani 1990a,b; Rahmani and Sankaran 1991; Isvaran 2005; Alfred *et al.* 2001), while the Chiru *Panthlops hodgsonii* and Tibetan Gazelle *Procapra picticaudata* dwell in the Himalayan mountain ranges that are scantily vegetated (Prater 1980; Menon 2003). The Four-horned Antelope is usually solitary but can be seen occasionally in loosely associated groups of three to five animals. The other antelopes usually have larger mean group sizes, with the exception of the Chinkara, which is found in smaller groups. However, even the Chinkara can be seen in groups as large as 17 in summer (Rahmani 1990b).

Different species have developed different morphological traits to serve as secondary sexual characters. The Four-horned Antelope is unique in having two distinct pairs of horns. The other known living species to have four horns is the domesticated Four-horned Sheep found in Britain and a Four-horned Chamois described once (Beddard 1902). Some Pronghorn Antelopes (*Antilocapra americana*) develop a split in their horns near the root, giving it the appearance of having four distinct horns, but since its family is now segregated from the antelopes as the Family Antilocapridae, there is no other known species of antelope that regularly grows four distinct horns. It is important to study the behaviour of animals to understand the evolutionary stimuli behind the development of such unique characters. Morphological features help animals in attracting mating partners, but their development into those of super-prominence is often checked by the costs they have to pay for it. An insight into the mating and anti-predatory behaviour of the Four-horned Antelope is expected to provide clues about the factors behind the development of two sets of horns in this small antelope.

We classified behavioural observations into three major classes, namely foraging, reproducing and predation avoidance. These three broad behavioural classes covered most of the activities recorded in the field. The three aforementioned categories were studied with an objective of understanding the ecology of the Four-horned Antelope. Its foraging and anti-predatory behaviour provide an understanding about the pattern of habitat use. Using these observations, an attempt was made to explain the possible relationships between the various behavioural traits observed in the field and to link them to the ecological and evolutionary biology of the Four-horned Antelope. An attempt was also made to relate its behavioural ecology with the niche that it occupies in the forest ungulate community.

## STUDY AREA

The Panna National Park is situated between the coordinates 24° 15'-24° 20' N and 80° 00'-80° 15' E towards the northern boundary of the state of Madhya Pradesh. It is 543 sq. km of Tropical Dry Deciduous Forest with an altitude ranging between 200 m and 550 m. Situated in the Vindhyan Hill Ranges, the terrain of Panna National Park is typified by extensive plateaux and gorges. It has a unique bench topography that discriminates the area into Hinauta (middle) and Talgaon (upper) plateaux respectively. The meandering Ken river splits the Park into valleys, steep slopes, cliffs, deep gorges and mud banks along the 54 km of its course through the Park. Along its course, the river goes beyond the Park boundaries for about 13 km from near Gangau village and re-enters near Kaneri village. The entire National Park acts as catchment to the Ken river and the area's major surface water flow is towards north and north-east. The Vindhyan sandstone provides a good medium to recharge aquifiers and at some places the water keeps trickling throughout the year from perennial springs.

## METHODOLOGY

### Opportunistic Focal Animal Sampling

Focal animal sampling (Altmann 1974) was used to study the behaviour of Four-horned Antelopes. However, systematic behavioural study using this method mandates prolonged observations of identified individuals. Four-horned Antelopes do not have any distinct morphological patterns (e.g. stripes, spots, unique horn/antler shapes) that may help identify individuals. Since no animals were radio-tagged during the study period, identification of individuals was difficult. All opportunistic sightings were considered as independent observations. The Four-horned Antelope lives solitarily or in very small groups. Random encounters of Four-horned Antelopes were sought, followed by specific efforts to get the animal accustomed to the observer's presence. Once located, individuals were observed as long as the observer was tolerated by the animal.

Between December 2002 and June 2005, Four-horned Antelopes were observed on 705 occasions (978 animals). Notes on their activities and behaviour were taken from 500 independent sightings in the field. Those animals that fled immediately after being detected were excluded from the analysis as it was difficult to judge their activity in the moments before they fled.

Between November 2002 and January 2003, a thorough survey of the study area was done, and areas with a high probability of sighting the Four-horned Antelope were identified. These sites were intensively surveyed thereon for locating and observing individuals. The Event Instances (frequency) and Event States (duration) of animals were recorded along with an additional variable denoting whether the animal was in a visibly disturbed or undisturbed state due to the presence of the observer. The Four-horned Antelope is shy and quite elusive in its escape tactics, and therefore an individual could be observed continuously for long durations (>10 minutes) on only a few occasions. The maximum duration for which an individual was observed was about 2.5 hours.

One of the constraints in this method of observing behaviour was in locating an individual, almost invariably the animal had to be in an active state when first seen. This bias was inevitable as the Four-horned Antelope prefers thick

undergrowth and grass with very low visibility for resting. The greatest number of behavioural observations could be obtained during 0600-1000 hrs and 1600-1900 hrs, presumably because it mostly rests during the hotter part of the day. However, occasional sightings were obtained at odd hours, for example at 1200 hrs, 1500 hrs and 2200 hrs.

Preliminary analysis suggested that the data obtained from the second and third years of study were different from those of the first year. Too many bouts of behaviour forced by the observer's presence (e.g. alert and alarmed positions) were obtained during the second year. This was possibly because the study team used a jeep during the first year and a motorcycle in the second. Covering the human figure in its silhouette, a jeep that does not make too much noise allowed a closer approach and longer observations of the animals. In contrast, motorcycles usually scared away the Four-horned Antelope inadvertently as these animals were usually shy and wary of conspicuous human figures.

**Midden Mapping and Monitoring**

The Four-horned Antelope, like many other ungulates (Leuthold 1977; Ranjitsinh 1982; Acharjyo *et al.* 1990; Biswas and Sankar 2002), has a tendency to defecate on middens. It was seen that many middens were shared not only by more than one individual, but also by different species. Nilgai, Chinkara and Four-horned Antelopes were often seen defecating on certain middens at different times of the day. A systematic approach was followed to understand the purpose of making and maintaining middens (Leuthold 1977; Black-Decima 2000). Middens were mapped and monitored over a period of 7 to 15 days. Faecal pellets can be used to provide evidence of the presence as well as abundance of an animal in an area (Neff 1968; Marques *et al.* 2001). Seven areas with a high encounter rate of Four-horned Antelopes were randomly chosen and demarcated. Thorough searches were done to locate and identify middens in these areas. A team of two to three observers walked along fixed paths, traversing a strip of width 5-10 m. On reaching the edge of the demarcated area, the adjacent strip was traversed when searching for middens. This exercise was repeated till the whole plot was searched. Physical barriers (cliffs, steep slopes, roads, etc.) were considered as boundaries for these demarcated plots when mapping them. The coordinates of each midden were noted with the help of a Global Positioning System (GPS), and it was classified on the basis of its size (Table 1). The status of the midden was estimated visually on the basis of pellet groups seen on it, and the species that seemed to have been defecating on it were identified. Once mapped, middens from a selected area were visited daily for five to seven days. The time of visit was chosen close to noon, on the assumption that most animals would be resting during the hotter periods of the day. Fresh defecations were identified and classified into the two categories of 'morning' and 'previous evening'. In addition, the species was identified and the number of pellets in a single defecation group counted. After noting information and collecting some fresh pellets, the fresh defecation was patted and pressed gently to flatten the heap. This was done to identify fresh defecations with certainty on the next day's visit. Since the stimulus for the antelope revisiting the midden was unknown, precautions were taken not to disturb the fresh pellet group's density and its position on the midden as this could have affected the next visit of the antelope. It was possible to distinguish pellets defecated by different individuals on a midden within a day's span as in most instances there were some diagnostic differences in shape, size, colour and placement of the defecation on the midden.

**Table 1**: Midden classes (based on midden diameter)

| Classification | Criteria |
|---|---|
| Order 1 | <50 cm |
| Order 2 | 50 cm to 1 m |
| Order 3 | 1 m to 2 m |
| Order 4 | >2 m |

**Cafeteria Experiment**

To investigate food preferences, cafeteria experiments were conducted on a captive Four-horned Antelope in Van Vihar National Park cum Zoo in Bhopal, Madhya Pradesh. The enclosure was about 275 sq. m in area, with Common Grass *Cynodon dactylon* and a Babool *Acacia nilotica* tree within it being the source of food. A single male Four-horned Antelope, about 18 months old, had been held captive for about 7 months. Five sessions of the cafeteria experiment were conducted in the enclosure in the last week of October 2002. These sessions were of 2 hours duration and would start early in the morning at about 0730 hrs and last till about 0930 hrs and start again at 1330 and continue till 1530 hrs.

Ten species of vegetation were provided to the animal, spread out in front of it in a semi-circular fashion so that it had equal access to all species. The species provided to the Four-horned Antelope were Ber *Ziziphus mauritiana*, Khair *Acacia cateclu*, Aonla *Emblica officinalis*, Renjha *Acacia leucophloea*, Babool *Acacia nilotica*, Amaltas *Cassia fistula* and the following grasses: Bamboo *Dendrocalamus strictus*, Lampa *Heteropogon contortus*, *Themeda triandra* and *Cynodon dactylon*.

## RESULTS

A total of 2,902 minutes (approximately 48 hours) of cumulative observation of the Four-horned Antelopes in the field was performed. Data were broadly classified into two categories, namely forced and natural behaviour. Forced behavioural bouts were those that were influenced by the presence of the observer. These were generally discarded for most analyses but were used for describing the threat response of the animal.

The natural behaviour observations were classified into Event States and Event Instances. This was done on the basis of the length of the bout of each of the different activities. Any behavioural bout occurring for less than a minute was considered as an Event Instance, whereas an Event State lasted a minute or longer.

This was done within the constraints of spotting an animal mostly when in an active state. Observations from waterholes were also made in different seasons. Three waterholes were identified, out of which one was a perennial spring, another was an artificial saucer and the third a check dam with water available till mid-summer. These waterholes were monitored three to five times every season, and observations of Four-horned Antelopes visiting them were recorded along with their detailed behaviour.

The main activity patterns that were not of the 'undisturbed' category were further classified into active and passive states. An active state was one in which the animal was on its feet, whereas a passive state was one in which an animal was either resting or ruminating. Active states were further classified into the following four major subclasses.

**Foraging**: When an individual was observed ingesting food, whether it was picking forage from the forest floor, browsing a shrub or nibbling herbs.

**Walking**: An activity where the animal was seen moving in a random or specific direction for over 10 m.

**Threat response**: Whenever the animal was in an alert position, sprinting or taking evasive action on seeing human or predators as a threat.

**Other activities**: All other activities were put together in this category as there were only a few recorded instances of some behaviour during our study period. While these could not be analysed statistically, they provided an insight into the natural history of a species whose behaviour was more or less unknown to science.

Any observation in which the animal was resting or ruminating was assigned to the passive mode. Activities were represented as the frequency of occurrence within an observation period. To avoid autocorrelation and to obtain independent behavioural bouts, animals were continuously observed within a timeframe, and only a change in an Event State or Event Instance was timed and recorded. Fig. 1 shows the percentage of time spent in the major classifications of behaviour in different time-slots.

### Threat Response

For each sighting in the field, notes were taken about the escape mechanism employed by the Four-horned Antelope. It was observed that on different occasions, different strategies were employed to evade potential threats. Whenever the animal did not take any evasive action, quietly moved, trotted, walked with stiff legs or just quickly vanished into thick vegetation, the behaviour was classified as 'minimum distress' or 'Quiet'. Situations in which the animal took clumsy leaps with or without curiosity or resorted to short sprints were ranked as 'short evasive manoeuvres' or 'Clumsy & Short'. Whenever the animal reacted nervously to threats and took to sprinting, the behaviour was termed as 'hyper-evasion' or 'Hyper'.

### Midden Mapping and Monitoring

Overall, 145 middens were identified and marked on the map after sampling six different areas. The spatial distribution of these middens in space was subjected to Poisson's test to investigate the level of clustering in the placement of these middens. Clustering would mean that the middens have an inductive effect and were possibly maintained by individuals, in order to demarcate home ranges or lure the other sex. It would also mean that their distribution across a habitat indicates visibility, accessibility and display rather than use of the respective habitat by the animal. The G-test for Poisson's (random) distribution was used to check clustering in space. We found that clustering was significant only in one area, namely Badi-saaj (chi square = 7.18; p = 0.00), which also had the highest number of direct sightings of the Four-horned Antelope (Table 3).

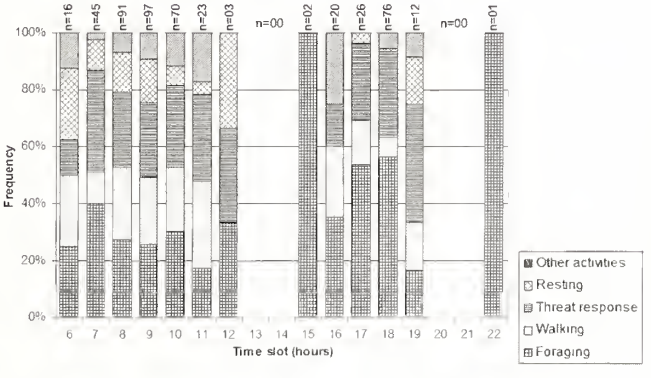


Fig. 1: Activity budgeting in terms of frequency of occurrence

## DISCUSSION

### Behavioural Classifications

#### (i) Foraging

The Four-horned Antelope is known to consume some grass in the early monsoon period and has specialised foraging preferences in other seasons (Rodgers and Panwar 1988). Preliminary data on foraging preferences of the Four-horned Antelope were obtained using the cafeteria experiment. As only one individual was available in captivity, the data do not have statistical robustness. Nevertheless, out of the 10 species of vegetation provided with equal access, 6 were consumed by the Four-horned Antelope in varying proportions (Table 2). None of the grasses were consumed, whereas *Zizyphus mauritiana*, *Acacia nilotica*, *Acacia leucophloea* and *Acacia catechu* were foraged in decreasing order of preference. Aonla and bamboo were consumed in small and insignificant proportions. Despite a lower preference in terms of the time spent in consumption, Babool was consumed before Ber, and in larger quantities. It was only after the stock of Babool was reduced that the animal moved towards Ber.

The captive Four-horned Antelope was alert and cautious when foraging. It would frequently raise its head and stop all other activities for a while before getting back to foraging. The level of alertness when foraging was much more than when it was ruminating or resting. The majority of the time between noon and evening was spent resting and sleeping in the shade. Occasional human disturbances also forced the animal to wake up and start ruminating after a certain period of caution had lapsed. Since a Babool tree inside the enclosure was in bloom, the Four-horned Antelope picked Babool flowers from the ground avidly. Interestingly, the animal preferred leaves to flowers when both were provided artificially, but consumed flowers whenever it found them on the ground. During the cafeteria experiment, the Four-horned Antelope showed no interest in ingesting any of the grass species other than nibbling some soft bamboo leaves on a couple of occasions.

**Table 2**: Food taken by the Four-horned Antelope during cafeteria experiment

| Species | Time spent (%) |
|---|---|
| Aonla (*Emblica officinalis)* | 3% |
| Babool *(Acacia nilotica)* | 31% |
| Bamboo *(Dendrocalamus strictus)* | 2% |
| Ber *(Zizyphus mauritiana)* | 43% |
| Khair *(Acacia catechu)* | 9% |
| Rencha *(Acacia leucophloea)* | 11% |

Foraging preferences of Four-horned Antelope are understood from limited direct observations (this study) and research with tamed animals under conditions that may or may not have reflected their native habitat preferences (Berwick 1974; Solanki and Naik 1998). The results of the other studies were similar to this one where the species showed a preference for nutritious plant parts, such as fruits, flowers, leaves over grass.

In the wild, the Four-horned Antelopes spent a significant amount of the observed time in foraging (Fig. 2). Jarman's (1974) hypothesis, re-established later statistically by Brashares *et al.* (2000), suggests that feeding selectivity is negatively correlated with body size and group size. Due to the volume: area ratio, smaller species require more energy per unit weight than do larger ones. Smaller antelopes have high metabolic requirements, but smaller stomachs in comparison to larger ruminants. This prevents them from taking large quantities of coarse forage that is high in fibre content and low in protein. As a result, smaller antelopes are more selective regarding their food. As with other antelopes of the same size (Jarman 1974), it is likely that since food that is high in protein content is scarce, the Four-horned Antelopes do not attain high abundances. The Four-horned Antelope seems to fit Jarman's hypothesis and tends to feed selectively. On almost all occasions when it was seen foraging, we examined the site after the animal had gone. The forage comprised mainly fruits, flowers, pods, or fresh leaves and petals, all high in nutritive quality. The animal was never seen grazing during the study period as was suggested by Rodgers and Panwar's (1988).

#### (ii) Resting

In a span of three years, we could observe Four-horned Antelopes resting only on 28 occasions. The difficulty in detecting animals resting in thick grass or undergrowth and their tendency to flush only as a last resort possibly resulted in such few observations.

**Table 3**: Patterns of middens within mapped areas

| Site | Mean | Std. Dev | $\chi^2$ (Poisson's) | P | Distribution |
|---|---|---|---|---|---|
| Pipartola | 2.67 | 1.55 | 6.87 | 0.29 | Poisson's |
| Badi Saaj | 1.67 | 1.55 | 7.18 | 0.00 | Clustered |
| Talgaon | 1.16 | 0.83 | 2.52 | 0.45 | Poisson's |
| Kwalan | 1.67 | 1.55 | 1.58 | 0.67 | Poisson's |

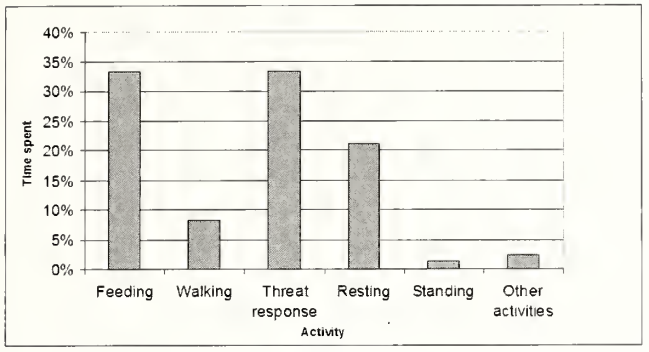


Fig. 2: Time spent in various activities as observed

Next to foraging and anti-predatory behaviour, the Four-horned Antelope displayed resting behaviour most frequently. The Four-horned Antelope prefers closed canopy thickets with dense undergrowth or grass cover for resting. Unlike the Chinkara, which invariably uses open terrain, forest clearings and forest roads for resting, the Four-horned Antelope was never found resting in the open. This observation is in contradiction with the conclusions arrived at by Bhaskaran (1999) who studied Four-horned Antelopes in Mudumalai and observed that they use forest roads for resting. We found that Four-horned Antelopes resting in the shade or in a thicket would usually flush only when the observer was less than 15 m away.

The Four-horned Antelope rests in the usual fashion of most ungulates. They fold their front legs, followed by hind legs, and bundle down, occupying the minimum possible space. Since the Four-horned Antelope usually rests in thickets with very low visibility, it is probably more dependent on its sense of hearing than its sight, when resting, to detect any disturbance.

Ruminating being an important aspect of the ecology of ungulates, they spend a significant amount of time performing this activity. The Four-horned Antelope usually ruminates while resting, but there were instances when an animal was seen chewing the cud even when standing. Out of the nine occasions when the Four-horned Antelope was observed ruminating, it was standing four times, whereas on the remaining occasions it was resting. Before ruminating, the Four-horned Antelopes spent a few minutes observing and assessing their ambience. Once the ambience was assessed, they twitched their stomachs with a slight jerk, which was followed by an apparent movement of the bolus through the oesophagus to the mouth.

**(iii) Interaction**

The Four-horned Antelope is a solitary animal. Since it is not usually seen in groups (69% solitary sightings, n = 824), there were few opportunities to directly observe interactions between individuals. Detailed behavioural notes could be taken on 41 individuals when they were in a group of two or more. Rapid scanning of the two or more individuals with a scan interval shorter than 1 minute was done, and overall, 341 behavioural bouts could be recorded. Sniffing, submission, trailing, mating and agonistic behaviour were the various events of interaction that could be observed on 40 occasions. On a few occasions, the Four-horned Antelope was seen interacting with other species as well, allowing inter-specific behaviour to be recorded.

**a. Intra-specific interactions**

**a.1. Mating**: A male and a female Four-horned Antelope were sighted at 0916 hrs on February 7, 2003. There had been brief showers during the previous few days. The pair moved briskly and briefly around a cluster of trees and bushes in the lower plateau of the Park, not more than 100 m from a steep cliff, in an open miscellaneous forest with medium undergrowth. On being observed, the Four-horned Antelope pair moved slightly away from the observers, and then the female started eating leaves of a low shrub. While the female was busy eating, the male approached her from behind and mounted her for about 2 seconds, to which female did not react at all and continued foraging. After dismounting, the male moved again and mounted her again, this time for a shorter duration, 1 second. Then the animals moved ahead and became attentive to passing villagers on a forest road, a few metres away. At 0919 hrs, the female ran away and was followed by the male till they both disappeared in the tall grass. The animals were rediscovered approximately 120 m from the first sighting spot, resting under a Tendu *Diospyros melanoxylon* tree at 1030 hrs. This time the animals did not react until the observers inadvertently flushed them out when they were just about 10 m away. The female and male ran swiftly in different directions instantaneously, but the male reunited with the female and joined her direction of movement after proceeding about 70 m. Later, attempts were made to relocate the pair in the area, but due to tall grass and bushy terrain, they could not be located.

**a.2 Submission**: A submissive posture can be defined as one where an individual shrinks its body, lowers the head and pulls the ears back. On April 16, 2003, two individuals were observed in a closed canopy area within a dense miscellaneous forest. The female started foraging after a short period of alertness, while the male remained alert and frozen. Circling around a cluster of bushes, the female approached the male and took a submissive posture, and the male sniffed her rear and started foraging. After a while, both the male and the female moved slowly while foraging selectively. After foraging for about half an hour, the male sat down in the

middle of medium height grass under an open-moderate canopy. The female sat down to rest after some time. It was evident that the pair was moving cohesively as we had a couple of relocations a few hundred meters away from the spot of the first sighting.

**a.3 Kneeling submission**: This is one of the most obvious and distinct interactions between two individuals, wherein an individual would approach another in a specific manner. Following a certain mode of communication, the other individual, not necessarily belonging to a particular sex or age group, would kneel down on its front legs with the rear of its body still up. The approaching individual would then come close and rub its neck with the kneeling antelope or examine it closely by sniffing it. This ritual usually lasted only a few seconds, after which both individuals would assume their normal postures. This behaviour was observed involving individuals of different sexes and age groups, once two fawns behaved in this fashion on being approached by an adult female. It seems that Four-horned Antelopes either communicate dominance and submission or use it to develop a bond with conspecifics with the help of such behaviour. This distinct behaviour was observed both in captive and wild Four-horned Antelopes. Shull (1958) also reported a kneeling 'courtship' between a male and a female Four-horned Antelope, which later mated.

**a.4 Trailing**: Following of an individual by another individual was categorized as 'trailing'. It was one of the most observed behavioural bouts involving any two individuals when seen together. Trailing was recorded on 46 occasions. It was mostly seen in fawns or juveniles following their mother, but occasionally it was observed in other age classes also, especially during the rutting season.

**a.5 Female-fawn/juvenile interaction**: The fawns seem to follow their mothers for almost a year or so. This was established on the basis of 41 direct sightings of fawns with females spread throughout the year. As determining the age was difficult in fawns, all individuals substantially smaller than adults (less than two thirds the size) were considered to be juveniles.

On five occasions a female was seen with a fawn and a juvenile. This proves that sometimes the juvenile moves with the mother even after she has given birth to another fawn. Whenever we saw a mother with a fawn or a juvenile, the latter followed the line of movement of the mother.

**a.6 Nursing**: On February 10, 2003, we saw a female suckling young ones. The two fawns were initially spotted by us. On the approach of their mother, they ran hastily towards her and started suckling, with one on either side of the mother and pushing persistently like the kids of a goat.

**b. Inter-specific interactions**

**b.1 Four-horned Antelope and Langur**: The Hanuman Langur *Semnopithecus entellus*, being mostly arboreal frugivores, usually forages on fruits and other vegetable matter in the trees. They are known to drop a mean of 4 kg of fresh vegetation per day (Newton 1989). It is also reported that for some species, such as the Aonla *Emblica officinalis*, fruit fall rates without Langur are as low as 1% of the fruit crop per day compared to when these trees are perched upon by Langurs. The relationship between the Chital and Langur is well-known and often referred to as a classical example of a commensal relationship. While some species like the Chital and Muntjac usually visit some fruiting tree species in small groups or pairs for short durations, with the presence of Langurs on the trees their group sizes increase and they spend longer durations foraging under these trees. This association is also known to have a key role in dispersal of plant species (Prasad *et al.* 2004). The Four-horned Antelope was seen associating with troops of Langurs for foraging on 20 occasions. It was seen foraging in association with Langurs under trees of Aonla, Bel *Aegle marmalos*, Bahera *Terminalia belarica*, Ghont *Ziziphus xylopara*, Kaitha *Feronia limonia* and Semal *Bombax ceiba*.

**b.2 Four-horned Antelope and Chital**: The Four-horned Antelope and Chital have an overlapping niche in dry deciduous forests (Berwick 1974, this study), where the former has a more widespread distribution than does the latter. The Chital, despite being a hardier and more generalist species than the Four-horned Antelope in terms of its foraging preferences, requires a greater extent of suitable habitat and larger amounts of food for its usually larger populations. Since the Chital lives in herds and the Four-horned Antelope is mostly solitary, the anti-predatory strategies of the two animals are different. Associations between two species with distinct anti-predatory behaviour and foraging preferences is rare but was recorded occasionally by us in Panna National Park. It was found that mostly at sites where Langurs were foraging on the top canopy, Chitals and Four-horned Antelopes were both seen benefiting from the items that were being dropped by the Langurs. Other than this, at some sites where closed forest stands were recently converted into open forests by uprooting of some trees, Four-horned Antelopes were occasionally seen foraging along with herds of Chital.

**b.3 Four-horned Antelope, parasites and Treepie**: Wild ungulates are hosts to ectoparasites and other insects (Krasnov *et al.* 2003; Miller *et al.* 2003; Wesonga *et al.* 2006 ). Some parasites play a major role in shaping the ecology and behaviour of the host species (Jog and Watve 2005). The seasonal distribution of some ungulates, including Four-horned Antelopes, changes in the monsoon, possibly due to

an explosion in the population of some parasites. It was observed that during the first two weeks of the monsoon, most ungulates possibly moved to the rockier areas of the study area. This was evident from the reduced encounter rate of Four-horned Antelopes in areas with a high incidence of parasites (Koustubh Sharma, unpubl. data).

The Treepie was the only bird which could be observed cleaning the ears of Four-horned Antelopes. It would perch on the root of the ear of a Four-horned Antelope, and the antelope would gently raise its head as if in acceptance of the act of cleaning. Treepies hang upside down when perching on the top of the ears of Four-horned Antelopes and pick ticks avidly while the animals stand almost still for getting the job done.

**(iv) Threat response (anti-predatory behaviour)**

An adult Four-horned Antelope weighs about 17-20 kg (Berwick 1974; Aniruddha Belsare pers. comm. 2007). Based on the relationship between body size, group size, feeding style and anti-predatory strategies of different antelopes of Africa, Jarman (1974) has proposed five social classes. Based on its size, weight and group size, the Four-horned Antelope seems to fit the description of Class A. According to Jarman's classification, antelopes from this category feed selectively on a wide range of plant species, use some plant parts only, remain in a restricted vegetation type and have a small home range. The feeding style of this class is further described as exclusive, as it feeds usually on single plant parts. These plant parts are removed wholly from the site. If animals classified as Class A feeders come to an area already fed upon by forerunners, they will have little to nibble upon as their forerunners would have either taken all of the acceptable items or would have at least consumed the more obvious or accessible ones. This is possibly one of the reasons why antelopes belonging to this class are solitary. As far as their anti-predatory behaviour is concerned, they depend largely on making themselves inconspicuous. In the presence of predators they freeze, lie down and freeze, or run to cover and freeze. Animals belonging to Class B also resort to similar tactics when it comes to dealing with a predator. They remain frozen until a predator is almost upon them and then take a short sprint to take themselves clear of the predator. Once at a safe distance, they hide again.

The Four-horned Antelope evades detection, and prefers hiding and freezing rather than fleeing instantaneously when it encounters a threat. It has a short flight distance, and only the crossing of this distance causes it to burst into a sprint.

**a. Freezing (no movement and mock feeding)**: When threatened, the Four-horned Antelope usually resorts to the tactic of standing still without any movements. We classified this behavioural bout as 'freezing' or 'alert'. A record was also maintained of the duration of all particular freezing bouts (with resolution in minutes). The duration of frozen alert was observed to last from a few seconds to 17 minutes. The success of this freezing technique is evident from an observation in the field on December 12, 2003, when a Four-horned Antelope standing still in grass of medium height evaded detection by a Leopard walking just 6 m away.

**b. Evasive action**: Those actions where the animal moved significantly in response to threats were called evasive actions. As the bout interval for these events was generally short, all these events have been termed as Event Instances, and instead of duration, frequencies are used to analyse their occurrence. These patterns were further classified as various behavioural displays were observed when the animal took evasive action (Fig. 3).

**c. Alarm calls (barking)**: The Four-horned Antelope sometimes make a shrieking alarm call. Its alarm calls are recurring, husky *pronk* calls repeated at regular intervals. It is rare to hear its alarm calls as its main anti-predatory strategy is to hide. These alarm calls are made only when the animal is faced with some special situations. Since the Four-horned Antelope is predominantly a solitary species, it is more likely that the alarm calls are used to warn the predator (Zahavi and Zahavi 1997; Reby *et al.* 1999; Bergstrom and Lachmann 2001) that it has been identified, rather than to warn conspecifics about the presence of a predator (Hauser 1996; Blumstein 2001).

The alarm calls are made at intervals of 5 to 10 seconds when the animal is standing, and at a much greater frequency of 0.5 seconds, when sprinting. These calls are diagnostically different from those of Chital and Nilgai as they are shriller than those of a Nilgai and huskier than those of the Chital Fig. 4 shows the spectrogram of the alarm calls made by a male which had sensed the presence of some predator and made alarm calls continuously for over 5 minutes.

**(v) Communication**

Olfaction plays a prominent role in the interactions of many ungulates with their environment. It is widely accepted that most forest-dwelling antelopes (e.g., Duikers and Kirk's Dikdik) and deer (e.g., Chevrotains and Muntjacs) rely primarily on their sense of smell for orientation and communication, as well as in the social context (Leuthold 1977; Geist 1987).

The modes of communication between Four-horned Antelopes are largely unknown apart from the alarm calls that are made in response to threats. The following modes of intra-specific communication were considered, based on our field observations.

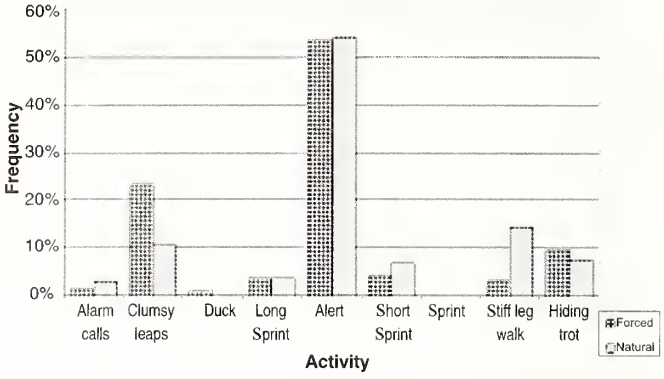


Fig. 3: Frequency of occurrence of events of anti-predatory behaviour (natural stimuli, n = 133; forced stimuli, n = 219)

**a. Preorbital gland marking**: A captive adult male was first observed in Van Vihar National Park of Bhopal marking the sharp tips of thorns and the fence wire with its preorbital glands. Only the adult male displayed this behaviour, whereas the younger male displayed no such activity. On many occasions in the wild, the Four-horned Antelope was seen marking with its preorbitals. Marking consisted of sniffing the twig or thorn and piercing it in its head sideways through the preorbital glands. This marking leaves a colourless liquid on the substrate. This liquid crystallises into a white solid film on the substrate within a few seconds of deposition. In the field, adult individuals, both male and female, were observed marking on twigs, thorns and grass tips with their preorbital glands. This method is widely used by many other territorial antelopes and deer (Brashares and Arcese 1999; Burger 2005). The habit of marking with preorbitals was displayed by both males and females, but was never observed in fawns.

**b. Urination and defecation**: Urination and defecation are perhaps the most generalised forms of scent marking. Biological waste also plays an important part in establishing the role of ungulates in stimulation of nitrogen cycling and retention, and modification of ecosystems (Hobbs 1996; Frank *et al.* 2000). It was observed that Four-horned Antelopes defecated regularly on middens. A couple of direct observations of defecation on such middens by males, females and even fawns prove that middens are also used as communication points. Mapping of middens and their periodical regular monitoring was done in order to understand the parameters influencing site selection and frequency of defecation on middens (Sharma 2006).

**c. Calling**: On two occasions, a Four-horned Antelope was heard making calls which were not very different from its diagnostic alarm calls, but with a lower amplitude. On February 6, 2004, a pair was seen courting. The male walked towards and away from the female while making distinct *cough* calls that were milder and more persistent than the alarm calls, and in a less strained posture (ears and feet movement relatively relaxed compared with the typical alert posture). On another occasion, where tiny fawns were observed hidden amidst thick undergrowth, the female made soft calls. After this call, the fawns proceeded in the direction from where she had called and vanished into thick vegetation.

It was also observed that adult female Four-horned antelope uses shrill calls that sound more like alarm calls to warn or communicate with its young ones. On one occasion a female approached a waterhole with her juvenile fawn. When the juvenile and the female were separated by about 30 m, the female got disturbed about some potential threat and burst into a long sprint, continuously making alarm calls at short intervals. The fawn, which was about a year old, followed her immediately after hearing the calls, without waiting to look around for the threat.

**Midden Mapping and Monitoring**

The way faeces are distributed in space is often indicative of an animal's social status. Voidance in one animal often induces the same in others (allelomimetic behaviour), particularly between mother and young, and even different species. To investigate midden maintenance behaviour, each of the identified middens was given a unique midden code for further reference.

Regular monitoring and a few direct observations revealed that the middens were used by both sexes and that

Fig. 4: Spectrogram of alarm calls made by the Four-horned Antelope

even the fawns accompanying their mother defecated on them. No determined and directional movement was observed specifically towards the middens, but apart from a few exceptional instances, faecal pellets were essentially released whenever a Four-horned Antelope came across a midden.

Identification of pellets was difficult at times when a Nilgai calf defecated on a midden as its pellets look similar to those of a Four-horned Antelope. Likewise, pellets of the young ones of Chinkara and Four-horned Antelope were also confusingly similar. To resolve this problem, based on direct observations of the three species defecating at middens on different occasions, we assume that a fawn will defecate on a midden only when accompanying its mother. This would mean that two fresh defecation heaps (one with small pellets and the other with bigger pellets) would be found on a midden whenever a young one had defecated on it. While there could surely be some deviations from this assumed behaviour, we never came across any direct observation contradicting this assumption.

The only area where clusters were observed was Badi Saaj. However, the reasons for such a clustering in this area are unknown, but could be probably credited to the high density of the population in this region (Sharma 2006).

## CONCLUSION

The Four-horned Antelope is elusive and difficult to be observed in most areas of its distribution. Other than a few observations, there are few studies on its behaviour. Although the data presented in this paper lacks statistical robustness due to inadequate data, it provides useful information about two critical aspects of an ungulate's natural history — its antipredatory strategies and its foraging preferences. Study of the phenology of the flora of Panna National Park, which is a dry deciduous forest, reveals that there is a continuous availability of palatable fruits, flowers or pods throughout the year in areas with high density of Four-horned Antelope (Sharma *et al.* 2007). This is an important factor for a species which needs to forage on high protein diet. Being a cryptic animal preferring to hide and freeze rather than sprint, Four-horned Antelope needs good undergrowth cover which is just right to hide, and at the same time helps it keep an eye on the predator. Areas that have extremely thick understories are usually avoided, and so are areas with no or minimal undergrowth.

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# NEW DESCRIPTIONS

## DESCRIPTION OF A NEW SPECIES OF *TYDEUS* KOCH (PROSTIGMATA: TYDEIDAE) INFESTING THE MEDICINAL PLANT *JUSTICIA ADHATODA* L. NEES WITH A NOTE ON ITS BIOLOGY

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One new species of *Tydeus* Koch (Family: Tydeidae) collected on the medicinal plant *Justicia adhatoda* L. Nees in West Bengal, India, is described here along with its life cycle.

**Key words**: *Tydeus*, new species, medicinal plant, *Justicia adhatoda*, life cycle

### INTRODUCTION

The members of the Family Tydeidae are small, soft bodied and active. These mites occur in a range of habitats including mosses, plants, lichens, soils and stored products. Some are plant feeders, some are predators, and food habits of many are related to honey dew and fungi (Mendel and Gerson 1982). Unfortunately, not much work has been done from the Indian subregion on the taxonomy and biology of Tydeid mites.

The present paper deals with the description and illustrates, along with the biology, of a new species of Tydeid mite of the genus *Tydeus* which is recorded for the first time from the common medicinal plant *Justicia adhatoda* L. Nees (Family: Acanthaceae) from West Bengal, India. Type specimens are deposited in the Entomology and Wildlife Biology Research Laboratory, University of Calcutta, which in due course will be deposited in Zoological Survey of India, Kolkata.

### MATERIAL AND METHOD

Collection and preservation of these mites were done following Gupta (1985). All the measurements given here are in microns.

***Tydeus justicia*** sp. nov. (Fig. 1)

**Female**: Propodosoma with four pairs of setae including a pair of sensory setae and hysterosoma with seven pairs of setae. Most of the setae on dorsal surface are thick, slightly curved and appear to be serrate. Striation in the propodosomal region longitudinal. Striation in the region between $d_1$ and $d_2$ transverse anteriorly, and slightly 'V'-shaped posteriorly; striation in the posterior-most region roundish; striation in the lateral region longitudinal. Chaetotaxy of palp and leg chaetotaxy as in Fig. 1. Measurements of body length, width, setae and legs are given in Table 1.

**Male**: Unknown.

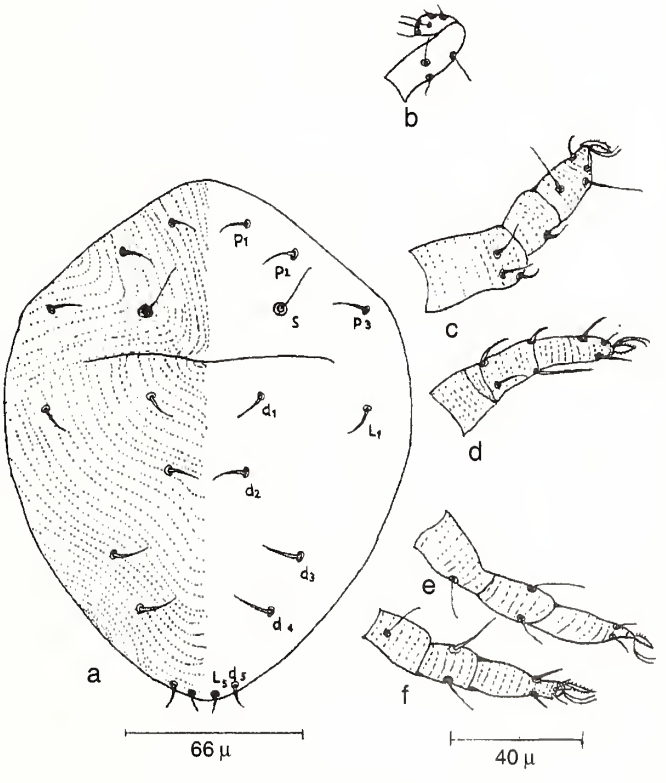


Fig. 1: *Tydeus justicia* sp. nov.:
a. Dorsal view; b. Palp; c. Leg I; d. Leg II; e. Leg III; f. Leg IV

**Material Examined**: Holotype: Female, Experimental Garden, Ballygunge Science College Campus, Kolkata, West Bengal, India, ex. *Justicia adhatoda*, dated: 2.x.2005, coll: Indranil Roy. Paratypes: 3 females, data same as for holotype.

**Etymology**: Named after the host genus *Justicia*

**Remarks**: This specimen resembles *Tydeus wallachi* Gupta and Chatterjee (Gupta 2002). The major differences being hysterosoma with 7 pairs of setae instead of 9 pairs in *T. wallachi*. Striation pattern on both the species differ, setae on legs are relatively shorter and palp chaetotaxy differ. This species also resembles *T. munsteri* Meyer and Ryke 1959, being differences exist in number and relative length of hysterosomal setae, as well as in striation pattern.

Adult individuals of *Tydeus justicia* sp. nov. were collected on *Justicia adhatoda* L. Nees leaf , and were reared in the laboratory for observing the life cycle. To study different developmental stages, the following method was followed. The leaves were cut into bits of 4 cm diameter and kept on a wet cotton pad in a Petri dish (10 cm diameter and 1.5 cm in height). Precautions were taken to remove all the unwanted organisms on the leaves by brushing; the excised leaves were examined under stereo binocular microscope. Then the adult females of *Tydeus justicia* sp. nov. were released (one on each Petri dish) on the leaf bits allowing them to lay eggs. On the next day, the adults were removed from the leaf leaving only the eggs in the petridish. The life cycle study of the mite was observed with the 12 freshly laid eggs of same age. Observations were recorded after every 12 hours to determine the duration of different developmental stages. After hatching, the larvae were lifted carefully with a 'zero' number hair brush and transferred to a previously prepared leaf-disc (at the rate of one larva/ leaf-disc/ Petri dish). The collected data on different developmental stages were subjected to statistical analysis. The study was conducted during September-October 2005 at mean room temperature and relative humidity of 28.03 °C and 83.05%, respectively.

The different developmental stages of *Tydeus justicia* sp. nov. included: egg, one larval stage, two nymphal stages and adult. The fecundity and the duration of individual stages are presented in Table 2.

**Table 1**: Measurements of body length, width, setae and legs of female *Tydeus justicia* sp. nov. (in microns)

| Characters | H | PA 1 | PA 2 | PA 3 | Mean |
|---|---|---|---|---|---|
| Body length | 221 | 221 | 222 | 221 | 221.25 |
| Body width | 148 | 146 | 148 | 147 | 147.25 |
| $p_1$ seta | 9 | 9 | 9 | 10 | 9.25 |
| $p_2$ seta | 10 | 10 | 9 | 10 | 9.75 |
| $p_3$ seta | 11 | 11 | 11 | 12 | 11.25 |
| S seta | 13 | 12 | 13 | 13 | 12.75 |
| $d_1$ seta | 13 | 13 | 12 | 13 | 12.75 |
| $d_2$ seta | 10 | 10 | 10 | 10 | 10 |
| $d_3$ seta | 13 | 14 | 13 | 13 | 13.25 |
| $d_4$ seta | 13 | 14 | 14 | 13 | 13.5 |
| $d_5$ seta | 8 | 9 | 8 | 8 | 8.25 |
| $L_1$ seta | 12 | 12 | 10 | 12 | 11.5 |
| $L_5$ seta | 12 | 12 | 12 | 13 | 12.25 |
| 1st leg | 72 | 72 | 72 | 70 | 71.50 |
| 2nd leg | 49 | 49 | 50 | 51 | 49.75 |
| 3rd leg | 66 | 65 | 65 | 66 | 65.5 |
| 4th leg | 69 | 69 | 70 | 72 | 70.0 |

H: holotype, PA 1: paratype 1, PA 2: paratype 2, PA 3: paratype 3

**Life cycle of *Tydeus justicia* sp. nov.**

**Eggs**

The eggs were elliptical, about 81µ in length and creamish white. They were laid singly on the under surface of leaves, adjacent to veins. The mean incubation period was 1.33 ±0.14 days.

**Larva**

The larva was white, with three pairs of legs. The mean larval period was 2.33 ±0.28 days. The larvae were sluggish and non-feeding type.

**Protonymph**

The protonymph was yellow, had four pairs of legs and was more active than the larvae; this period was 1.83 ±0.17 days.

**Deutonymph**

The deutonymph was bigger than the protonymph and orange in colour. The mean deutonymphal period was 2.17 ±0.17 days.

**Adult**

Adults were slightly bigger than deutonymphs and were red in colour. The adult longevity was 16.5 ±0.95 days.

**Table 2**: Fecundity and duration of different developmental stages of *Tydeus justicia* sp. nov. under laboratory condition

| Stage | Range (in days) | Average (in days) | Duration ± SE (in days) |
|---|---|---|---|
| Egg | 1-2 | 1.33 | 1.33 ±0.14 |
| Larva | 1-5 | 2.33 | 2.33 ±0.28 |
| Protonymph | 1-3 | 1.83 | 1.83 ±0.17 |
| Deutonymph | 1-3 | 2.17 | 2.17 ±0.17 |
| Egg to Adult | 5-10 | 7.67 | 7.67 ±0.47 |
| Adult | 12-22 | 16.5 | 16.5 ±0.95 |
| Fecundity | 6-11 eggs | 7.75 eggs | 7.75 ±0.69 eggs |

**Egg to Adult**

The mean duration of egg to adult period was 7.67 ±0.47 days.

**Fecundity**

The average total fecundity was 7.75 ±0.69 eggs in the species studied.

## DISCUSSION

The life cycle of *Tydeus justicia* sp. nov. reached adulthood in about 8 days on the host plant *Justicia adhatoda*, whereas in the related species *Tydeus californicus* it took about 12 days on two host plants *Weigela* sp. and *Vitis vinifera* L. Sangiovese (Liguori *et al.* 2002). In the present experiment, the average fecundity appeared to be very poor as evident from the fact that it was only 7.75 ±0.69 eggs per female. As per Liguori *et al.* (2002), *Tydeus californicus* viviparously generates 26 larvae in her life span of about 44 days on grape and 32 larvae in about 48 days on *Weigela* sp., respectively. On the other hand, it is apparent that the life cycle of *Tydeus* species takes almost similar time as that of Tetranychid mite (Gupta 1985) and Phytoseiid mite (Gupta 2003), but in case of Tenuipalpid mite, the life cycle takes much longer time than these mites, where the mean time taken from egg to adult period was 11-26 days (Jeppson *et al.* 1975) in case of *Brevipalpus obovatus*.

## ACKNOWLEDGEMENTS

The authors are thankful to the Ministry of Environment and Forests, Govt. of India for their financial assistance and to the Head, Department of Zoology, and the Head, Department of Botany, University of Calcutta, for the facilities provided.

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# A NEW SPECIES OF THE GENUS *TETRALEURODES* COCKERELL (HEMIPTERA: ALEYRODIDAE) OF INDIA, WITH A KEY TO THE INDIAN SPECIES

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The whitefly genus *Tetraleurodes* Cockerell from India is reviewed. A new species *Tetraleurodes thassammaiae* breeding on *Actinodaphne* sp. in Singampara (Palakkad), Kerala, India, is described and illustrated. A key to the Indian species of the genus is given.

**Key words**: Whiteflies, Hemiptera, *Tetraleurodes*

## INTRODUCTION

The whitefly genus *Tetraleurodes* Cockerell is represented by 69 described species almost worldwide (Martin and Mound 2007). In India, this genus is so far represented by seven species. A new species of this genus from southern India breeding on *Actinodaphne* sp. in Singampara (Palakkad), Kerala, India, is described with a key to the Indian species in this paper.

1. ***Tetraleurodes bambusae*** Jesudasan & David

*Tetraleurodes bambusae* Jesudasan and David 1991. *Oriental Ins. 25*: 332.

**Material Examined**: INDIA: Goa (Qupem): 5 puparia on *Oxytenanthera stocksii*, 21.ix.2008, R. Sundararaj.

**Host**: *Bambusa* sp. (Jesudasan and David 1991); *Oxytenanthera stocksii* (new host record).

**Distribution**: INDIA: Tamil Nadu (Jesudasan and David 1991); Goa (new distribution record).

**Discussion**: This species is rather distinct from the other species of *Tetraleurodes* in possessing sculptures on the dorsum.

2. ***Tetraleurodes burliarensis*** Jesudasan & David

*Tetraleurodes burliarensis* Jesudasan and David 1991. *Oriental Ins. 25*: 332-333.

**Material Examined**: INDIA: Tamil Nadu (Burliar): holotype puparium, on unidentified tree, 20.vi.1985, R.W.A. Jesudasan.

**Host**: Unidentified tree (Jesudasan and David 1991).

**Distribution**: INDIA: Tamil Nadu (Jesudasan and David 1991).

**Discussion**: The puparium of this species can be easily recognized by the absence of dorsal, mesothoracic and metathoracic setae.

3. ***Tetraleurodes dendrocalamae*** Dubey & Sundararaj

*Tetraleurodes dendrocalamae* Dubey and Sundararaj 2005. *Zoos' Print Journal 20(7)*: 1924-1926.

**Material Examined**: INDIA: Karnataka (Kudremukh National Park): holotype puparium, on *Dendrocalamus strictus*, 10.viii.2001, A.K. Dubey.

**Host**: *Dendrocalamus strictus* (Dubey and Sundararaj 2005).

**Distribution**: INDIA: Karnataka (Dubey and Sundararaj 2005).

**Discussion**: This species can be easily separated from the other known Indian species by the presence of submedian setae on meso- and metathorax and submargin with a row of microtubercles.

4. ***Tetraleurodes kunnathoorensis*** Regu & David

*Tetraleurodes kunnathoorensis* Regu and David, 1993. *Hexapoda 5(1)*: 53-56.

**Material Examined**: INDIA: Tamil Nadu (Kunnathoor): holotype puparium, on *Streblus asper*, 21.i.1991, K. Regu.

**Host**: *Streblus asper* (Regu and David 1993).

**Distribution**: INDIA: Tamil Nadu: Kunnathoor (Regu and David 1993).

**Discussion**: The puparium of this species is readily recognizable by the presence of submarginal setae in 5 pairs and subdorsal setae in 10 pairs.

5. ***Tetraleurodes pusana*** Takahashi

*Tetraleurodes pusana* Takahashi 1950. *Annot. Zool. Japan 23*: 86.

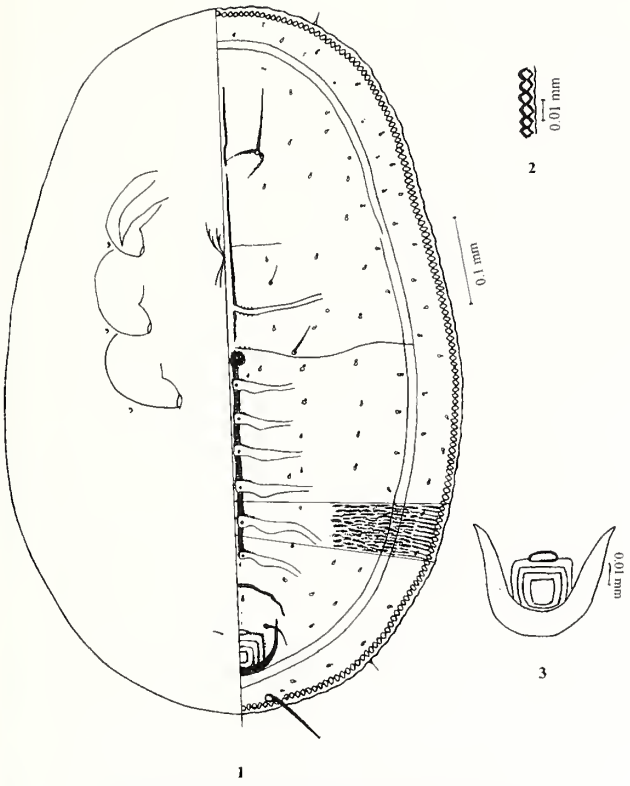
*Tetraleurodes pusana* Jesudasan and David, 1991. *Oriental Ins. 25*: 333.

**Material Examined**: INDIA: Tamil Nadu (Madras): 1 puparium on grass, 5.xii.1971, B.V. David.

**Host**: Unidentified Grass (Takahashi 1950).

**Distribution**: INDIA: Bihar (Pusa) (Takahashi 1950); Tamil Nadu (Jesudasan and David 1991).

**Discussion**: Yellowish-brown puparium with no wax and presence of long cephalic and metathoracic setae and dorsum without granules and sculptures serve to distinguish this species from other Indian species of *Tetraleurodes*.




Figs 1-3: *Tetraleurodes thassammaiae* sp. nov.
1. Puparium, 2. Margin, 3. Vasiform orifice

**6. *Tetraleurodes rubiphagus*** David & David

*Tetraleurodes rubiphagus* David and David 2007. *Oriental Ins. 41*: 406.

**Material Examined**: INDIA: Tamil Nadu (Kalakkad): holotype puparium on unidentified plant, 1.v.1993, P.M.M. David.

**Host**: Unidentified Plant (David and David 2007).

**Distribution**: INDIA: Tamil Nadu (David and David 2007).

**Discussion**: This species can be distinguished from other known Indian species by the presence of fine wax filaments on the dorsal disc of the puparium and by the presence of at least 3 pairs of submarginal setae and by the absence of dorsal setae.

**7. *Tetraleurodes thenmozhiae*** Jesudasan & David

*Tetraleurodes thenmozhiae* Jesudasan and David 1991. *Oriental Ins. 25*: 333-334.

**Material Examined**: INDIA: Tamil Nadu (Burliar): holotype puparium on *Cinnamomum* sp., 20.vi.1985, R.W. Alexander Jesudasan.

**Host**: *Cinnamomum* sp. (Jesudasan and David 1991).

**Distribution**: INDIA: Tamil Nadu (Jesudasan and David 1991).

**Discussion**: This species is distinguished from other Indian species of *Tetraleurodes* by its white puparium with a distinct suture-like line running from the cephalothoracic region to eighth abdominal segment on subdorsum.

**8. *Tetraleurodes thassammaiae* sp. nov.**

Sundararaj & Pushpa (Figs 1-3)

**Description**

**Puparium**: White, without secretion of wax; elliptical, broadest at first abdominal segment region; 0.84-0.86 mm long, 0.52-0.58 mm wide; found in groups on the lower surface of leaves. Margin toothed, teeth rugose and arranged in two rows, 16-18 teeth in 0.1 mm. Thoracic and caudal tracheal pores not differentiated from margin. Anterior and posterior marginal setae each 6 µm long.

**Dorsum**: Dorsum with rows of pores and porettes, subdorsum with faint wavy markings, submedian area smooth, segment sutures distinct, each abdominal segment suture with a ridged rim and a pair of microtubercle on submedian area, submedian pockets present in all abdominal segment sutures. Submargin separated from dorsal disc by a prominent complete submarginal furrow; submargin irregularly and faintly striated. A median longitudinal ridge extending from 7$^{th}$ abdominal segment towards cephalad parallel to the longitudinal moulting suture connecting abdominal segment sutures 1-6 and all thoracic segment sutures. A prominent median tubercle on 1$^{st}$ abdominal segment, microtubercles along the metathoracic and transverse moulting suture in the median area distinct. Longitudinal moulting suture reaching margin and transverse moulting suture reaching near submarginal furrow. Base of cephalic setae granulated.

**Chaetotaxy**: 6 pairs of setae – cephalic setae 80 µm long, mesothoracic setae 10 µm long, metathoracic setae 20 µm long, first abdominal pseudosetae set close to the median line 2 µm long, eighth abdominal setae cephalolaterad of vasiform orifice 40 µm long and caudal setae arising from submarginal microtubercle 75 µm long. Vasiform orifice elevated, open, subrectangular, 54-56 µm long, 40-50 µm wide; operculum subrectangular, 28-38 µm long, 20-24 µm wide, lingula concealed. Thoracic and caudal tracheal furrows absent.

**Venter**: Paired ventral abdominal setae 14-18 µm long, 50-54 µm apart. Antennae reaching the base of prothoracic legs. Spiracles visible.

**Host**: *Actinodaphne* sp.

**Distribution**: INDIA: Kerala.

**Material Examined**: **Holotype**: One puparium, on *Actinodaphne* sp., mounted on slide, Coll. R. Sundararaj, 22.x.2006, deposited in the collection of Forest Research Institute, Dehradun (NFIC # 21888).

**Type Locality**: INDIA: Kerala: Singampara (Palakkad).

**Paratypes**: Eight mounted puparia, data same as holotype, deposited one each in the collections of Division of Entomology, Indian Agricultural Research Institute, New Delhi; Zoological Survey of India, Kolkata (2447/H15) and the remaining in the collection of Institute of Wood Science & Technology, Bengaluru.

**Discussion**: This species can be readily recognised from other known species of *Tetraleurodes* in the presence of mesothoracic and metathoracic setae, first abdominal pseudosetae and subrectangular vasiform orifice, but differs in shape and by the absence of microtubercles on dorsum.

**Etymology**: Named after Smt. Thassammai, mother of the senior author.

### Key to the Indian species of *Tetraleurodes*

1. Puparium black or bluish black ..... 2
— Puparium pale yellow or yellowish brown or white ..... 5
2. Dorsal setae/meso-, metathoracic setae/submarginal/ subdorsal setae present ..... 3
— Dorsal setae/meso-, metathoracic setae/submarginal/ subdorsal setae absent..... *burliarensis* Jesudasan & David
3. Submedian setae on meso- and metathorax absent; submargin without a row of microtubercles; vasiform orifice cordate or subcordate; 8-10 teeth in 0.1 mm ..... 4
— Submedian setae on meso- and metathorax present; submargin with a row of microtubercles; vasiform orifice subrectangular; 16-18 teeth in 0.1 mm ..... ..... *dendrocalamae* Dubey & Sundararaj
4. Puparium with fine wax filaments present only on dorsal disc in nearly 3 circles, but absent from margin; minute submarginal setae at least 3 pairs; subdorsal setae absent; submargin devoid of polygonal to rounded markings ..... ..... *rubiphagus* David & David
— Puparium with very little wax around margin and on dorsum; submarginal setae in 5 pairs; subdorsal setae in 10 pairs; subdorsum with dense polygonal to rounded markings ..... ..... *kunnathoorensis* Regu & David
5. Puparium pale yellow or yellowish brown; only metathoracic setae present; submarginal furrow incomplete; first abdominal segment without a median tubercle ..... 6
— Puparium white; meso and metathoracic setae present; submarginal furrow complete; first abdominal segment with a median tubercle ..... *thassammaiae* sp. nov.
6. Puparium pale yellow with wax around margin; cephalic and metathoracic setae short; dorsum with granules and sculptures ..... 7
— Puparium yellowish brown with no wax; cephalic and metathoracic setae very long; dorsum without granules and sculptures .....*pusana* Takahashi
7. Dark brown patch on dorsum absent; marginal setae wanting; cephalic setae 17.5 µm long, metathoracic setae 12.5-15.0 µm long and eighth abdominal setae 17.5 µm long; vasiform orifice wider than long *thenmozhiae* Jesudasan & David
— A distinct dark brown patch on dorsum present; marginal setae present; cephalic setae 38 µm long, metathoracic setae 43.7 µm long and eighth abdominal setae 27.5-40.0 µm long; vasiform orifice as long as wide ..... ..... *bambusae* Jesudasan & David

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# REVIEW

MULTIPURPOSE PLANTS by P.K. Srivastav, Published by Scientific Publishers (India), Jodhpur, Rajasthan, India. 2008. 354 pp. Size: 24.5 cm x 19 cm. Hardback. Price: Rs. 1,650/- (INR).

The literature on plant wealth of India dates back to the *vedas*. It is well-known that Ayurveda has dealt in detail with the medicinal properties of around 700 plants. During the British regime numerous explorations undertaken to study the natural resources of India expedited the documentation of this wealth. There are umpteen books published since then that deal with various plant resources of the country. For instance, THE USEFUL PLANTS OF INDIA: WITH NOTICES OF THEIR CHIEF VALUE IN COMMERCE, MEDICINE AND THE ARTS by C.H. Drury was published in 1873, which compiles extensive information on 600 herbs and tree species of India. THE WEALTH OF INDIA series is an almost complete account of commercially exploited plants in the Indian subcontinent. With this background, the book MULTIPURPOSE PLANTS by P.K. Srivastav generates curiosity about the novelty of its content.

The tome is an account of 159 indigenous, as well as exotic, plant species brought under cultivation since long. The species included in the work are non-agricultural shrubs or trees. Each of these are described with a detailed account of their botanical and popular names (in foreign, as well as Indian languages), systematic position, geographical distribution (global and within India), habitat, habit, morphological characteristics, floral formula, flowering and/ or fruiting periods, varieties, uses, and different ways of propagation. This information, as the author states in the 'Introduction', is largely a compilation of information from several secondary resource materials. In addition, first hand information on the status of sericulturally important food plants has been incorporated on the basis of his vast experience, expanding over 31 years.

A note on the methods of cultivation of each species is a special feature, which is rarely found in previous accounts on this topic. The author has provided the systematic position of each species in three systems of classification, namely Bentham and Hooker, Engler and Prantle, and Hutchinson; and for some species even Benson. The morphological information also includes floral formula. These two features make superfluous stuff irrelevant to the subject. The easily readable print of the book and the minimal use of technical words in descriptions may support the claim by the author that the book will create interest among common people. However, the unnecessary information, even for individuals with scientific background, would definitely repel common people.

Photographs depicting 64 plant species are of poor quality. For example, photographs of *Heteropanax fragrans*, *Aegle marmalos*, *Cedrela toona*, *Hardwickia binata*, *Machilus bombycina*, *Syzigium cumini*, *Tamarindus indicus* are 'zoomed out' images and one can hardly see any key characters to identify the species. Similarly, the photographs of *Datura metel*, *Dalbergia sissoo*, *Litsea salicifolia*, *Ricinus communis*, *Zizyphus mauritiana* are of poor print quality. The picture of *Litsea zeylanica* is wrongly identified/labelled. The genus of *Acacia auriculiformis* and *A. arabica* on the first illustration page is wrongly spelt as '*Accacia*'.

The species are arranged alphabetically as per their scientific names, though the title of the species profile is its most popular common name. A strong drawback is the absence of an index both, scientific as well as common names. If one has to look for a particular species, using the common name, one has no option but to flip through pages.

Also, the book fails to mention the current conservation status of these species. Though most of these species are cultivated, and do not fall in threatened categories. However, in case of species with narrow geographical distribution, a comment on their rarity or commonness would have been relevant.

The book certainly brings a lot of information in a nutshell, and will be useful for beginners and students.

■ SWAPNA PRABHU

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# MISCELLANEOUS NOTES

## 1. ABNORMAL MATING BEHAVIOUR OF TUFTED GRAY LANGUR, *SEMNOPITHECUS PRIAM* AT KALAKAD-MUNDANTHURAI TIGER RESERVE, TAMIL NADU, INDIA

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The Kalakad-Mundanthurai Tiger Reserve is one of the few protected areas in southern India where five primate species, including Lion-tailed Macaque *Macaca silenus*, Nilgiri Langur *Trachypithecus johni*, Tufted Gray Langur *Semnopithecus priam*, Bonnet Macaque *Macaca radiata* and Slender Loris *Loris tardigradus*, occur (Johnsingh 2001). Except the Lion-tailed Macaque, others are found in the Mundanthurai plateau extending to an area of 50 sq. km with an altitude of 180 m (above msl) and surrounded by two major rivers, the Karaiyar and Servalar. Primate studies in the plateau include research on Nilgiri Langur (Sunderraj and Johnsingh 2001) and on Slender Loris (Gupta 2003).

The Tufted Gray Langur has a discontinuous distribution in the plateau. The present observations were made in the last week of December 2006 at the Mundanthurai plateau. Three Tufted Gray Langurs were observed by the first author near the Mundanthurai Guest House. Tufted Gray Langur was known to occur in the lower Pappanasam dam and Pothigaiadi, which are five and eight km, respectively, away from the Mundanthurai Guest House. The first author followed and observed the behaviour of three male langurs in the office complex at Mundanthurai. They primarily depended on the kitchen wastes discarded from the Guest House rather than forage in the forest interiors. A troop of Bonnet Macaques also depended on the discarded materials from the guest house.

The first author recorded one Tufted Gray Langur going behind a female Bonnet Macaque, when she was in heat. The focal female Bonnet Macaque had a broken tail and the vagina was visible to the Langur. Later, many interactions were recorded and the number of approaches made by the Tufted Gray Langur was recorded. Initially, the Langur maintained considerable distance (4-10 m) from the focal female Bonnet Macaque. Later, as a response to the vaginal discharge that increased on the next day, the Langur frequently approached the female Bonnet Macaque for copulation. Frequent agonistic interactions were observed between the Tufted GrayLangur and alpha male of the Bonnet Macaque troop. A total of 32 such interactions were noticed in a day at different timings and the Langur always remained and foraged with the Bonnet Macaque troop on the first day. On the morning of the third day, the Tufted Gray Langur was observed pseudo mounting the female Bonnet Macaque. While doing so, the dominant male Bonnet Macaque interrupted; the same behaviour continued on the next day. However, on the next day the female Bonnet Macaque did not give any chance for making pseudo mounts. This mode of interaction between the Tufted Gray Langur and Bonnet Macaque has never been reported earlier; however, an interaction between a male Nilgiri Langur and a female Tufted Gray Langur (Johnsingh *et al.* 1986) was reported earlier from the plateau. A probable reason for such inter-species mating behaviour may be the absence of female langurs in their troop.

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## 2. FURTHER CHANGES IN THE EASTERN LIMIT OF DISTRIBUTION OF THE HANUMAN LANGUR *SEMNOPITHECUS ENTELLUS* DUFRESNE

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The general distribution of Hanuman or Gray or Common Langur *Semnopithecus entellus* Dufrense, covers almost the entire India, excluding the deserts and the snow-capped higher Himalaya. Groves (2001) proposed a full

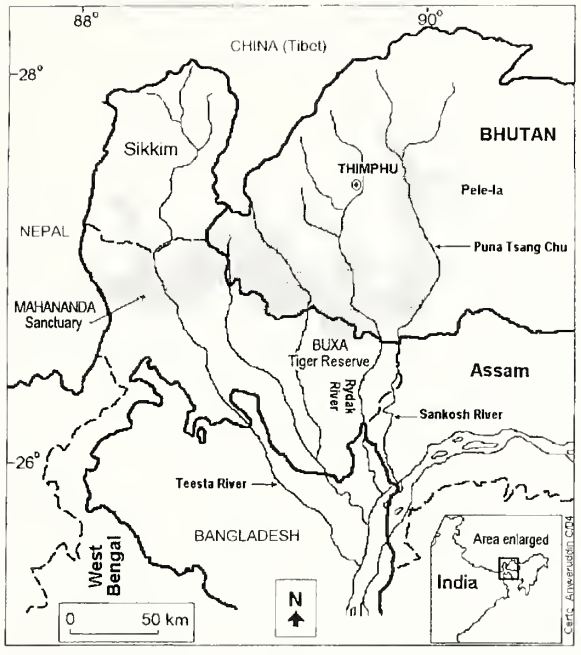


Fig. 1: Eastern-most range of Hanuman or Common Langur

specific treatment for different extant subspecies of the Hanuman Langur. Although it is a very well-documented species, the eastern limit of its distribution was imperfectly known with different authors suggesting erroneous eastern ranges (Roonwal and Mohnot 1977; Tikader 1983; Corbet and Hill 1992; Das *et al.* 1995; Qiu and Bleisch 1996). Choudhury (2007) tried to fix it as the Rydak river in northern West Bengal, India, and Sankosh river or Puna Tsang *Chu* in Bhutan, and Padma and Meghna rivers in Bangladesh (historically Jamuna also).

As indicated in other reports (Wangchuk *et al.* 2004) and as found during recent visits to Bhutan (Choudhury 2008), the Hanuman Langur also occurs east of the Sankosh river or Puna Tsang *Chu* up to Pele-la (Fig. 1) in Wangdue Phodrang *dzongkhag* (= district). Hence, in India and Bangladesh, the eastern limit is marked by large rivers, while in Bhutan a large river in the southern part and a high mountain ridge in the north, act as the zoogeographic barriers.

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## 3. THE COMMON INDIAN MONGOOSE *HERPESTES EDWARDSII* AS SEED DISPERSER IN SRIHARIKOTA ISLAND, INDIA


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The Common Indian Mongoose *Herpestes edwardsii* is a carnivore, but fruits and roots have also been recorded in its diet (Prater 1971; Menon 2003). In this short communication, we provide further evidence of the Common Indian Mongoose as a fruit eater, and more importantly as a seed disperser from a study on frugivory in Sriharikota Island, Nellore district, Andhra Pradesh. On April 16, 2007, we observed small droppings scattered on the roadside and some more deposited underneath parapets of a cable network. All scats were clumped within a 5 sq. m area and were approximately 8 m away from the nearest fruiting tree. The droppings were small (*c.* 2 cm in length), and our tribal (Yanadi) field assistant told us that the scats were those of the mongoose, which was confirmed on finding the footprints

of the species close to the droppings. The droppings of Mongoose were hard to find and we came across it only on three occasions during the study period.

On examination of 28 of the droppings collected we counted 362 seeds of *Phoenix farinifera*, a small (3 m tall) date palm species common in Sriharikota. Later, we also recorded seeds of *Grewia rhamnifolia* and *Syzigium cumini*. In Sriharikota, the Golden Jackal *Canis aureus* and Small Indian Civet *Viverricula indica* are the major dispersers of these three plant species (David *et al.* 2008).

According to Balasubramanian and Bole (1993), the Common Indian Mongoose does not play a significant role in seed dispersal as it eats the pulp and drops the seeds under the parent plant. However, our observations in Sriharikota suggest that the Common Indian Mongoose is a probable legitimate seed disperser as seeds were recorded in its faeces. Other than the mongoose, small carnivores like Badgers, Martens and Civets are known to play a role in seed dispersal and facilitate germination (Herrera 1989; Rabinowitz 1991; Zhou *et al.* 2008). Hence, small mammals like the mongoose must be intensively evaluated for their role in seed dispersal.

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# 4. HIGHEST ELEVATIONS REACHED BY ASIAN ELEPHANTS *ELEPHAS MAXIMUS* LINN. – A REVIEW


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The Asian Elephant *Elephas maximus* Linn. occurs across south and south-east Asia, from peninsular India and Sri Lanka to Sumatra and Borneo (Corbet and Hill 1992; Choudhury 1999). It occurs in the plains as well as hills, occasionally moving to higher areas. The highest mountain range within and near its distribution range is the Himalaya. How far up the species has ascended has been a matter of great interest and curiosity.

The first published attempt to find out the highest occurrence of Asian elephants was by Capt. Molesworth (1914). He mentioned of 3,109 m at Bhutan-Tibet boundary, which he recorded during the Aka expeditions. He mentioned that the elephants move up during hot weather. This area is apparently somewhere in the present West Kameng district of Arunachal Pradesh because the Aka tribes inhabit there. Although, the boundary of both Bhutan and Tibet is nowhere nearby, it is understandable that about a century back clear demarcation on the inaccessible mountains was difficult.

Shebbeare (1915) while quoting Mr. Tinne of the Forest Department stated that elephants ascend at all seasons at Rechila and Sathila in British Bhutan, at 3,066 m to feed on bamboos. Even tracks were seen in 0.6 m snow in April 1907. Elwes (1916) while supplementing Shebbeare (1915) said that "in August 1886 I made a trip with Mr. Prestage from Darjeeling up the Rishila or Rechila with the object of finding a shorter and better route into the Chumbi Valley. For some miles the only path that then existed was made by wild elephants, and our camp below the summit at about 2,743 m was disturbed in the night by a herd. But I was assured by my friend, the late Mr. C.B. Clarke, FRS, that on one of his botanical expeditions into eastern Sikkim, he had seen elephants' tracks in the snow at about 3,657 m".

Betts (1947) mentioned that "While crossing the Bompu La (2,926 m) in early September I was surprised to find fresh traces of a large number of elephants..." He further stated that the ringal bamboos growing there attracted the elephants during the summer months. He, however, did not pin point the location and no subsequent writer except Choudhury (1999) highlighted the site.

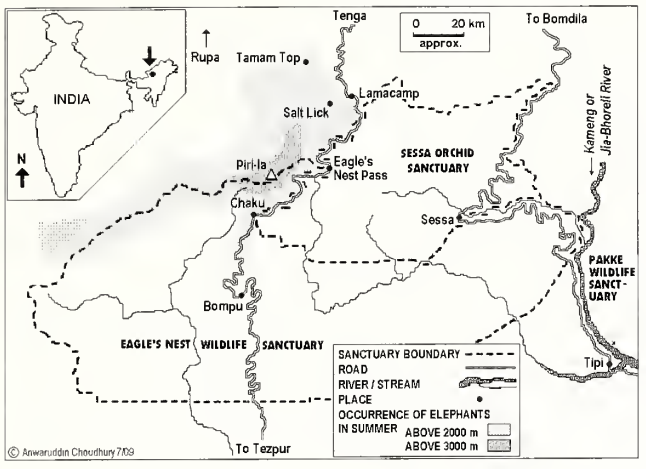


Fig. 1: Map of Eagle's Nest Sanctuary and Piri-La ridge showing high elevation summer range of elephants in western Arunachal Pradesh

The sites mentioned by Molesworth (1914) and Betts (1947) appeared to be the same and will be discussed later in detail. Those of Shebbeare (1915) and Elwes (1916) are located in the present day Neora Valley National Park of Darjeeling district, West Bengal, and adjacent areas of Sikkim (Pangolakha Wildlife Sanctuary, East Sikkim district) and Bhutan (Samtse or Samchi district). However, there is no recent report of occurrence in this part of Sikkim or Bhutan although the pachyderms move considerably high up in the Neora Valley, but all such movements are in summer and not in all seasons as mentioned by Shebbeare (1915).

The sites of Molesworth (1914) and Betts (1947) are somewhat difficult to locate for people unfamiliar with eastern Himalaya as Molesworth (1914) mentioned of a general area and latter just Bompu La. Presently, there is no place called Bompu La but there is a station having camps of road construction labourers known as Bompu (27° 04' N; 92° 24' E) in West Kameng district, Arunachal Pradesh. It is through this place that the old Foothills – Bomdila road passes. The highest point on road is north-east of Bompu, known as Eagle's Nest Pass at 2,850 m elevation (27° 07' N; 92° 28' E). Eagle's Nest appears to be the new name for Betts' (1947) Bompu La? The mountain ridge above Eagle's Nest Pass is known as Piri-La, whose highest point is 3,200 m high. Piri-La apparently refers to a pass on an old foot track, but is now also the name of the ridge as well as the peak. Many of these locations are now inside Eagle's Nest Wildlife Sanctuary and Sessa Orchid Sanctuary (Fig. 1).

I had the opportunity to work in the area in the 1990s (Choudhury 1999, 2003). I observed dung, footprints as well as live animals in the area including Piri-La (27°07' N; 92°25' E), which has a nice topography and enroute there were several smaller flat areas with pools and abundant ringal bamboos. The elephants start ascending in late March or early April and remain there till end-October. They move from south-west of Piri-La towards north and north-east up to Tamam Top (27° 10' N; 92° 27' E; south of Tenga and south-east of Rupa) for about 5-6 months before starting to descend at the onset of winter when the area experiences snowfall.

While ascending they follow the main road (gravel road) from Bompu to Chaku; some directly ascend Piri-La while others continue through the road via Eagle's Nest Pass to Lamacamp. Interestingly, the villagers and visitor's follow the trail made by elephants while ascending Piri-La (including me). The animals which directly ascend Piri-La follow the crest line of the mountains, which is not rugged but rolling for their subsequent movement and foraging. The elephants which travel through the road to Lamacamp mainly affect the roadside areas at Eagle's Nest Pass, where some flat and rolling areas are present with abundant bamboos, and near a large pond with salt lick and ringal bamboos near Lamacamp. The elephants cannot descend from the ridge to the road at most stretches of the road owing to steep slopes and cliffs. Most of the animals (except for some lone bulls) mingle again above Lamacamp at Tamam Top.

While descending, the elephants take both the routes till Chaku, but it is not known (unless some animals are radio-collared) whether the same animals are passing through. So far as the number of elephants is concerned, they were found to be in family groups or small herds of 7-10 animals. Although congregations have not been encountered, on Piri-La and Tamam Top, where the flat or rolling ground is relatively large with abundant ringal bamboos and grass, herds of 20+ were reported by locals who occasionally pass through on foot. The total number of elephants spending their summers at such height is estimated to be between 50 and 80.

The road in question (Foothills-Bompu-Chaku-Eagle's Nest Pass-Lamacamp-Tenga) is largely a disused one with only a few vehicles of Border Roads Organisations (BRO, GREF, BRTF, etc.) and hunter's plying on it. but it was under widening and improvement for all-weather traffic between Tezpur and Bomdila till such steps were shelved a few years back owing to possible damage to the sanctuaries. This remains the major threat for future also, which might stop such interesting migration of the elephants to such a height every year.

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# 5. FIRST SIGHT RECORD OF ASIATIC IBEX *CAPRA IBEX SIBRICA* FROM KUGTI WILDLIFE SANCTUARY, CHAMBA, HIMACHAL PRADESH, INDIA


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Snow Leopard survey was conducted in Uttarakhand and Himachal Pradesh by WWF-India in 2008. Kugti Wildlife Sanctuary (KWLS) was one of the study areas for collecting the information on direct and indirect evidences of Snow Leopard, co-predators and their prey. KWLS is situated in the Chamba district of Himachal Pradesh, India. It represents the Biogeographic zone-2A of North-West Himalayas (Rodgers and Panwar 1988). On November 14, 2008, while surveying from Duggi to Relang and scanning surrounding mountains for evidence of wildlife, an Asiatic Ibex *Capra ibex sibrica* was sighted at location 32° 39' 55.1" N and 76° 46' 39.5" E. It was a group of five individuals, of which two males could be identified. The animals' identity was ascertained from the pointed beard, and shape of horns that were thick scimitar-shaped (Prater 1998; Menon 2003). The sex of the remaining animals could not be determined due to long distance (about 100 m) and low visibility.

They appeared for about three to four minutes and went to the other side of the hill. The group of Ibex was sighted at an elevation of 3,700 m at the southern aspect. These were at 50° slope and in a shrubland. The vegetation consisted of grass (40%) and shrub (60%). This was the first sighting of Asiatic Ibex in the KWLS. Only indirect evidences were recorded so far (G.S. Rawat and S. Sathyakumar pers. comm.). Apart from Asiatic Ibex *Capra ibex*, Brown Bear *Ursus arctos*, Goral *Nemorhaedus goral* and Monal Pheasant *Lophophorus impejanus* were also sighted during the survey.

The Asiatic Ibex is a wild goat, and male can easily be identified by the thick scimitar-shaped horns and pointed beard. Female can be identified by the smaller size and thin parallel horns. The coat is dark brown with dull white saddle patches. It is distributed in the mountain ranges (3,650 m to 6,700 m) of western Himalayas, i.e., west of Sutlej in Himachal Pradesh and western Ladakh (Menon 2003). It prefers steep slopes and in the spring they are found low below the snow-line, attracted by the new sprouting grass where they usually graze early in the morning and evening.


## ACKNOWLEDGEMENTS

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# 6. RECENT STRANDING INCIDENCES OF MARINE MAMMALS IN WEST BENGAL, INDIA

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One of the most fascinating features of Indian biodiversity is its marine mammals, which include members of seven different families under two Orders. The families Delphinidae, Phocoenidae, Physeteridae, Ziphiidae, Balaenopteridae and Balaenidae belong to Order Cetacea, and Dugongidae belongs to Order Sirenia. Records of marine mammals in India, along with its location status, are well-documented by Sathasivam (2000). There is some literature which gives taxonomic features, species abundance and status of conservation of the marine mammals in India (Corbet and Hill 1992; Molur *et al.* 1998; Agrawal and Alfred 1999; Lal Mohan 1999; Kumaran 2002; Alfred *et al.* 2005; Alfred *et al.* 2006). Literature review shows that there are a total of 408 mammal species recorded so far in India; this includes 29 species of marine mammals out of 120 recorded in world (Jefferson *et al.* 1993). According to the IUCN (2003) and Alfred *et al.* (2006), the status of marine mammals in Indian waters was; 3 endangered, 3 vulnerable, 8 insufficiently known and 6 under lower risk. However, the Indian Wildlife Act (1972, amended in 1991) (as mentioned in Alfred *et al.* 2005) lists only 4 species of cetaceans, i.e., Irrawaddy Dolphin, Ganges River Dolphin, Sperm Whale, and Dugong in Schedule I, and 15 species are included in Schedule II. Lack of adequate scientific information could not provide any status on the remaining species. The present paper covers recent stranding evidences of marine mammals, especially whales and dolphins, along West Bengal coast. This stranding record will help in fulfilling the information gap on this group by providing first hand baseline information of their abundance. The finding will also help the various ongoing and future research studies on this topic, as well as managers for successfully implementing conservation laws in the area. Comparison of earlier records of stranding on Indian coasts till 2000 shows that most of the incidences were recorded on the east than west coast. However, West Bengal had meagre incidences of occurrences of marine mammals. The state-wise sighting records of stranding of marine mammals in Indian coasts till 2000 is shown in Fig. 1.

During the present study, the first incidence occurred in the first week of May 2006 at Jhelampur beach near Mandarmoni in East Midnapore district, West Bengal. The stranding site was immediately visited to record observations on overall morphology, dimensions, flipper size, part of skeleton, and skull of whale. Some observations were also made from indirect evidences like interviewing locals and fishermen. In addition to this incidence, another dead whale was recorded at the same place about a kilometre away on May 16, 2006. All the diagnostic features recorded were used to draw conclusion on species identification by using keys given in Prater (1980), Jefferson *et al.* (1993), and Agrawal and Alfred (1999). The following observations could be made from the available specimen in these two stranding incidences:

1. The overall morphology of the specimen was largely damaged, but some patches of intact skin appeared black dorsally and grayish ventrally.
2. The body length of the first whale was about 17 m and that of the second was 15 m of which the head was around 35%.
3. The jaw bones could be observed clearly with damaged baleen plates and bristles. The baleen plates were dark with horizontal grey bands. Head was V-shaped with a prominent central ridge over it.
4. There were around 65-75 ventral furrows.
5. Dorsal fin was distinct, but small and sharply angled and placed at the posterior 1/3rd of the back. It measures around 0.4-0.5 m, which was approximately 2.5% of body length. Pectoral flippers were sickle-shaped and curved towards the end. Tail fluke horizontally flattened and blade-shaped, which was not supported by bone.

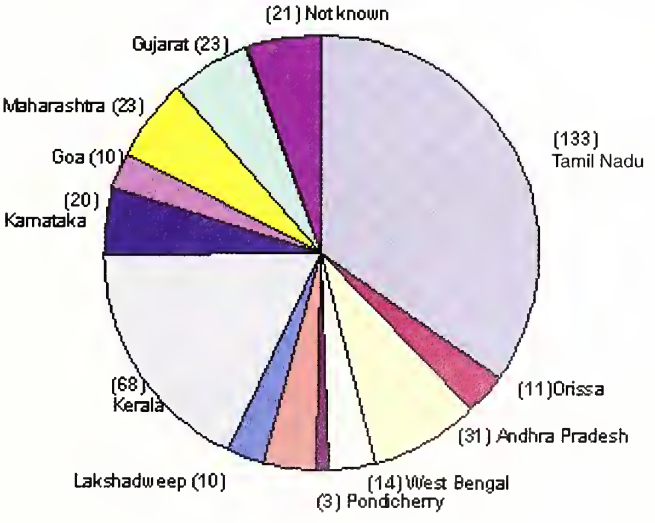


Fig. 1: State-wise sighting records of marine mammals in India

6. Dorsal fin, flippers and fluke black. Flippers and fluke white below.
7. Body colour was dark grey above and white underneath. Colour of head was not uniform dorso-ventrally. Upper jaw was grey with white fringes, however, lower lip and palate white in colour.
8. The undigested intestine or stomach mass largely contained crustaceans. As the whale died in open water before stranding, most of the gut content was decomposed and beyond identification up to species level.
9. Blow hole could not be noticed as a part of the head portion was detached.

From the recorded diagnostic features, it appears that these two species belong to Genus *Balaenoptera* under Family Balaenopteridae. Close observations of the distinguishing features suggests that it was a Fin Whale *Balaenoptera physalus* (Linnaeus). The prominent distinguishing features of Fin whales observed in the present case were asymmetrical coloration pattern, moderate sized dorsal fin, V-shaped head with pointed tip, gray baleen plates with white streaks and black back. Fin whales are distributed worldwide. In the Indian Ocean, there is a continuous presence of these whales. As far as the north-east coast is concerned, this is the first incidence of Baleen whale occurrence. In 1967, one dead whale species was recorded near Junput coastal area (Fisheries Dept. West Bengal pers. comm.); this species was, however, not identified. Sightings of Baleen whales were earlier reported off Kolkata and Mumbai coasts by de Silva (1987) (as reported in Agrawal and Alfred 1999). Sathasivam (2000) and Kumaran (2002) recorded 12 specimens of Fin Whale from Indian waters, which were mainly stranding and landings. Five vertebrae of one Baleen whale were also reported by de Silva (1987), which was displayed in Medical College, Kolkata, but the stranding site was not reported.

Along with these two whale stranging records, one small-sized dead sea mammal was also recorded at the same location about 100 m away on the morning of May 16, 2006. The overall morphology was not much damaged like in earlier incidences, except neck and abdomen portion. The diagnostic features of this mammal are as follows:

1. Colour of body was blackish dorsally and greyish ventrally.
2. Body length was about 2 m.
3. Mouth was located ventrally with powerful jaws and pointed snout. The teeth were flattened and around 16 in the upper jaw, the lower jaw was damaged.
4. Eyes were small and bulging.
5. Head was blunt without beak as in other dolphins and with a bulbous forehead and distinct neck.
6. Blow hole was damaged.
7. The pectoral fin was like flippers, which had curved edges and rounded tips.
8. Tail was narrow and compressed horizontally.
9. Dorsal fin was very small and the tip portion was damaged.

From the available evidences it appears that the species was of Order Cetacea, Family Delphinidae. It is commonly known as Irrawaddy Dolphin *Orcaella brevirostris* Gray. There are a few reports on sighting and stranding of Irrawaddy dolphins from Indian waters (Sathasivam 2000; Kumaran 2002). Along the east coast of India, the sightings were also reported by James *et al.* (1989) in Bhitarkanika Sanctuary, Dandapani (1992) in Chilka lake, and Miller (1997) in Chennai Coast.

The fourth incidence of a stranded dead marine mammal was recorded at Digha-Mohana on May 18, 2006. At first it appeared like some fish, but careful observation revealed that the animal was a mammal. The local fishermen informed that this mammal was stranded for 3-4 days. The diagnostic features recorded from this specimen are as follows:

1. Colour of the body was greyish-black with spots.
2. Body length was 2.3 m.
3. Mouth and teeth were damaged, but a beak-like structure could be seen from the skull.
4. The pectoral fin was flipper-shaped and falcate.
5. Tail was compressed and fluke notched in the middle.
6. Dorsal fin was black, backwardly pointed and located in the middle of the body.

From the available evidence, it appeared to be a Pantropical Spotted Dolphin *Stenella attenuata* Gray 1846. Sathasivam (2000) and Kumaran (2002) reported 13 specimens from Indian waters, de Silva (1987) reported 4 specimens.

It is noteworthy to mention that all these four cases occurred in the duration of one month and within a few metres. These incidences draw attention to the need for collective long-term monitoring studies in this area to determine the reasons and patterns of stranding. Movement of large vessels in the nearby port Haldia, one of the busiest ports in India, offshore and land-based pollution, and high sediment load through nearby estuaries are some of the existing threats in this area and should be considered when formulating further studies. The movement of large animals in such areas often cause accidents, which may prove fatal to the animals. Awareness among locals, fishermen and managers also need to be addressed for effective implementation of environmental and conservation laws. The present observation within a month indicates presence of these previously unreported mammals in the area. The area can be converted into an important eco-tourism site. This will be an added attraction

for the tourists in Digha, Shankarpur and Mandarmoni beaches already famous tourist destination for North-eastern states.

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# 7. SIGHTING OF LEUCISM IN SPOT-BILLED DUCK *ANAS POECILORHYNCHA* J.R. FORESTER, 1781 AND LITTLE GREBE *TACHYBAPTUS RUFICOLLIS* (PALLAS, 1754) IN DISTRICT DUNGARPUR, RAJASTHAN, INDIA

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Leucism is an abnormal plumage; though uncommon it occurs occasionally in many species. While albinism is a genetic mutation that prevents the formation of the pigment melanin, leucism occurs when this pigment is diluted causing paler plumage that is often cream or sometimes white.

On February 04, 2009, a single individual of Spot-billed Duck with white plumage was sighted in the Gamela pond of Chhota Bodigama village, Dungarpur, Rajasthan. The entire body was white, except for the head (Fig. 1).

Spot-billed Duck *Anas poecilorhyncha* J.R. Forester, 1781, is a large-sized widespread resident duck found all over the Indian subcontinent (Ali and Ripley 2001, HANDBOOK OF THE BIRDS OF INDIA AND PAKISTAN TOGETHER WITH THOSE OF BANGLADESH, NEPAL, BHUTAN AND SRI LANKA. Oxford University Press, Bombay). Normal individual of Spotbilled Duck has scaly-patterned buffy grey and dark brown plumage.

Fig. 1: Spot-billed Duck *Anas poecilorhyncha* with leucism

Likewise, on August 09, 2008, we sighted a single individual of Little Grebe with white upper parts and crown in the Gamela pond of Bankoda village in district Dungarpur, Rajasthan. The bird was prominent among the other grebes in the area.

Little Grebe *Tachybaptus ruficollis* (Pallas, 1764) is a small, tailless, aquatic resident bird found all over the Indian subcontinent Ali and Ripley (2001). In normal individuals, the upper parts are dark brown with darker crown and sides of head, neck, and throat chestnut.

Fig. 2: Little Grebe *Tachybaptus ruficollis* with leucism

## 8. STATUS OF WHITE-HEADED OR AUSTRALIAN STILT *HIMANTOPUS LEUCOCEPHALUS* IN SRI LANKA

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The White-headed Stilt (= Australian Stilt) *Himantopus leucocephalus* was first recorded from Sri Lanka by the second author on November 18, 1995 (De Silva 1996, 2000a). Since then there have been more records of the species from Sri Lanka (Table 1). All sightings are from the south-eastern quarter of Sri Lanka during the winter migratory season (i.e., approximately between mid-November and mid-April).

In general, the birds are solitary while in Sri Lanka, but there are a few reports of the White-headed Stilt being seen in the company of its congeners the nominate Black-winged Stilt *Himantopus himantopus* - a common species in many Sri Lankan wetlands. On December 07, 2003, some Black-winged Stilts were observed attacking and chasing a pair of White-headed Stilts (W. Kulasuriya pers. comm.). White-headed Stilts can easily be differentiated in the field from the Black-winged Stilts by their white heads and elongated black hindneck feathers, which form a sharply defined raised hindneck patch or ridge (De Silva 2002). A few Black-winged Stilts may occasionally have a dark hindneck but, even so, they can easily be separated from the White-headed Stilts, as their hindneck feathers are not elongated (i.e., they are of the same length as the other neck feathers), the dark hindneck patch is not sharply defined and the head is often suffused with grey (De Silva 2000b, 2002).

**Table 1**: Sightings of White-headed Stilt *Himantopus leucocephalus* from Sri Lanka

| Date | Location | Observers/(Comments) |
|---|---|---|
| November 18, 1995 | Bundala National Park | R.I. De Silva. |
| December 16, 1995 | Bundala N.P. | P.T.G. Perera and R.I. De Silva. |
| January 07, 1996 | Bundala N.P. | D. Perera and R.I. De Silva. (4 birds). |
| April 11, 1997 | Bundala N.P. | A. Kirtisinghe and R.I. De Silva. |
| January 21, 1999 | Palatupana | Dr. H.I.E. Katugaha. |
| December 05-08, 2003 | Bundala N.P. | Prof. S.W. Kotagama, C.D. Kaluthota, Ms. Y. Karunaratne, N. Jayawardane, R. Amarasekera, I. Kaggoda Arachchi, and U. Wickremasinghe. |
| December 07, 2003 | Bundala N.P. | W. Kulasuriya and U. Wijesena. (2 birds). |
| April 06, 2005 | Bundala N.P. | Prof. S.W. Kotagama, M.G. Bellio, C.D. Kaluthota and S. Gamage. |
| November 12-15, 2005 | Bundala N.P. | Prof. S.W. Kotagama, W. Kulasuriya, U. Wijesena, D.R.S. Illangakoon, D. Jayatilleke, M.S. Anver, S.M.N. Bulathwela, Ms. T. De Silva, N. Anurudda and J. De Silva. |
| March 04, 2007 | Bundala N.P. | B.C.G. de Zylva. |
| March 21, 2007 | Bundala N.P. | C.D. Kaluthota, K. Dayananda, H. Sathischandra and D.R. Vidanapathirana. |
| March 24, 2007 | Bundala N.P. | R. Perera. (Photographic evidence provided). |

This raises an interesting question: Do White-headed Stilts breed with the Black-winged Stilts, and if so, does cross-breeding occur in Sri Lanka? While positive evidence for this is lacking, some tantalizing clues suggest that they could do so. In 2001, a national newspaper published the photograph of a stilt in Ruhuna National Park (south-east Sri Lanka) with features of both the White-headed and Black-winged Stilt (photographic evidence provided). Authorities, who examined the photograph, suggest that the bird is probably a hybrid of the White-headed and Black-winged Stilt (De Silva 2003). There are a few other sightings of similar birds from the south-eastern quarter during the winter migratory season. While the possibility of interbreeding between the two species is suggested by these observations, the question is where such possible hybridization could occur. As White-headed Stilts and the (putative) hybrids are recorded in Sri Lanka mainly during the winter migratory season, it is unlikely that interbreeding would occur in the Island. Any possible hybridization would therefore conceivably take place where the home-ranges of the two species overlap during the breeding season. This suggests the Indonesian region, where the White-headed and Black-winged stilts occur together for much of the year.

It is significant to note that (as in Sri Lanka) White-headed Stilts visit India during the winter migratory season (Lopez and Mundkur 1997; Kotagama 2005). Since the majority of records of White-headed Stilts are from the eastern regions of India and the south-eastern quarter of Sri Lanka, it suggests strongly that the birds probably arrive in both countries from home-ranges which are farther East; once again suggesting the Indonesian region. White-headed Stilts appear to be expanding their range in the Oriental region. As indicated above, the first author (SWK) has photographed White-headed Stilts in Sri Lanka and has shown that the species was known from India for many years (Kotagama 2005). (The Natural History Museum in Tring, has a specimen labelled "from British India" dating back to the 19th century). In addition to Sri Lanka, the species has been recorded from India (Lopez and Mundkur 1997; Kotagama 2005), South-east Asia (Nial Moores pers. comm.), Indonesia (Hayman *et al.* 1987) and Japan (Akira Hibi pers. comm.). Some authorities (Tony Prater, C.S. Roselaar, and Ray Pierce pers. comm.; De Silva 2000b) suggest that the White-headed Stilts visiting Sri Lanka could come from Sumatra or Java.

It is now clear that the White-headed Stilt is an irregular winter visitor to Sri Lanka in small numbers (Kotagama *et al.* 2006). We further suspect that the birds visiting India and Sri Lanka may be a part of a post-breeding dispersal.

The occurrence of White-headed Stilts in Sri Lanka and the possibility of hybridization with the nominate are interesting phenomena which merit further observation and study.

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# 9. REDESCRIPTION OF JAPANESE CATALUFA *PRISTIGENYS NIPHONIA* (CUVIER & VALENCIENNES, 1829): A NEW DISTRIBUTIONAL RECORD FROM SOUTH INDIAN WATERS

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***Pristigenys niphonia*** (C & V 1829) - Smith 1966
*Myriptistis refulgens* Val. 1862 : 1169 (Seychelles)
*Priacanthus refulgens* Sauvage, 1891 Hist. Nat. Madag. Poiss 16: 129, Pl 5, fig 5 (E. coast Madagascar)
*Pristigenys macropthalmus* (Agassiz, 1835)
*Pricanthus niphonia* Cuv. & Val., 1829 Hist. Nat. Poiss.

*3*: 107 (Japon). Schlęgel, 1843, Fauna Jap.: 21, Pl. 7a (Japon)

*Pseudopricanthus niphonia* Bleeker, 1869 and 1876 - Atl. Ich. Pl 352, fig 3 (Celebes). Smith 1963, Fishes Seychelles: 13, Pl 9, B.

Agassiz (1835) first listed *Pristigenys substriatus* (without description) as a new combination for *Chaetodon substriatus* (Blainville, 1818), a fossil species of Eocene Monte Bolca Formation in Italy, which was earlier erroneously reported by Volta (1796) as the present day species *Chaetodon striatus*. Agassiz (1839) gave a short description of this species and considered it to be a genus near *Beryx*. As a consequence, it was listed in the Family Berycidae in the classification of fossils by Woodward (1901) and Eastman (1905). However, after Agassiz 1839, Bleeker (1869) described the genus *Pseudopriacanthus* to include *Pricanthus niphonius* Cuvier, 1829. Morrison (1889) formally named this species as the type of the genus and also allocated *Priacanthus altus* Gill and *Priacanthus meyeri* Gunther (as a synonym of *niphonius*) to the group as did Boulenger (1895). However, the genus *Pristigenys* was not included until a century after its description. White (1936) had first noted the similarity between the genus *Pristigenys* and *Pseudopriacanthus* in question, synonymized them, and transferred *Pristigenys* from Family Berycidae to Priacanthidae, hence the name *Pristigenys* and *Pseudopriacanthus* are used interchangeably. Since there is no contrary evidence, Fritzsche (1981) recommended that all recent species of *Pseudopricanthus* be referred as *Pristigenys* based on the suggestions of White (1936) and Myers (1958).

Simultaneously, numerous brief descriptions in various classifications and regional faunal works, literature dealing exclusively with Priacanthidae as a group started with that of Bleeker (1873) who had given description on the species of Indonesian region; Morrison (1889) reviewed the American species; Boulenger (1895) and Fowler (1931) described the species *Pristigenys niphonia* of Japanese waters. Caldwell (1962) and Randall (1978) reviewed the western Atlantic species; and Eggleston (1974) the western Pacific and eastern Indian Ocean. Myers (1958) and Smith (1966) gave comparative descriptions for the species under the genus *Pristigenys*. Starnes (1988) gave a review on the genus *Pristigenys* and its phylogenic relation with other species of the Family Priacanthidae of Indo-Pacific region.

Though several species of Family Priacanthidae have been reported from the Indian waters, none of the species of the genus *Pristigenys* were reported so far, except by Philip (1994) who recorded *P. niphonia* based on a single specimen collected from Wadge bank (7° N; 77° E). Recently, nine specimens of *P. niphonia* were collected from the demersal trawl catches of the vessel *Matsya Varshini* (36.5m OAL; GRT-268.8 tonnes) of Fishery Survey of India, during the period 1999-2002, during an intensive survey carried out in the Wadge bank and Gulf of Mannar for the perch resources of this region. Description of the species with the salient features of the skeletal structure are also given in this paper. A redescription for this species was given based on the nine specimens collected from the same area. Meristic counts and measurements were taken following Starnes (1988). Potassium hydroxide solution (5%) was used for cleaning the bones for osteological studies. In naming the various bones the works of Berg (1940), Starnes (1988) and Cannon (1987) were followed.

Abbreviations for anatomical terms used in the text figures are as follows:

AR = articular; B = basipterygium; BH = basihyal; BrR = branchiostegal ray; C = cleithrum; CC = Coracoid; CH = ceratohyal; D = dentary; DHH = dorsal hypohyal; ECT = ectopterygoid; EH = epihyal; Ep = Epural; H = hyomandibula; HH = hypohyal; HP = hypural; IH = interhyal; IO = interopercle; M = maxilla; MES = mesopterygoid; MET = metapterygoid; O = opercle; PA = parietal; PC = postcleithrum; PG = pectoral girdle; PH = Parahypural; PL = palatine; PM = premaxilla; PO = preopercle; PS = pectoral spine; PTT = post-temporal; Q = quadrate; S = scapula; SC = supracleithrum; SOP = subopercle; SY = symplectic; UH = urohyal; VHH = ventral hypohyal.

**Description**

D. X+ 11 P.17-18 V. I+ 5 A III +10 Ll. 36-37; LS. 40; VRS. 33-35; Gr. 5-7 +17-19 (22-26); scales of midlateral area with 22-24 (smaller specimens) and 27-33 (in larger specimens) spinules and 23 vertebra.

**Diagnosis**

Body ovate, highest overall width found immediately behind the operculum. Fourth and fifth dorsal spines are longer than the rest. Soft part of the dorsal and anal fin broadly pointed. The pelvic fin soft rays of younger specimens (58.5 mm) reaching beyond the anal fin origin and falling short in larger size group (> 210 mm). Teeth (canines) differentiated into large and small; the outer series of upper jaw is wider and larger than the lower jaw.

**Colour**: Body reddish orange, head, fins and operculum red to silvery. Five silvery white bars on head and body, where the first bar at first dorsal fin origin, pass through posterior end of the operculum and extending to the base of the pectoral fin. Second beneath the fourth and fifth dorsal spine extending to belly and third bar originated just beneath the ninth dorsal fin and extending to first anal spine, fourth and fifth bars at

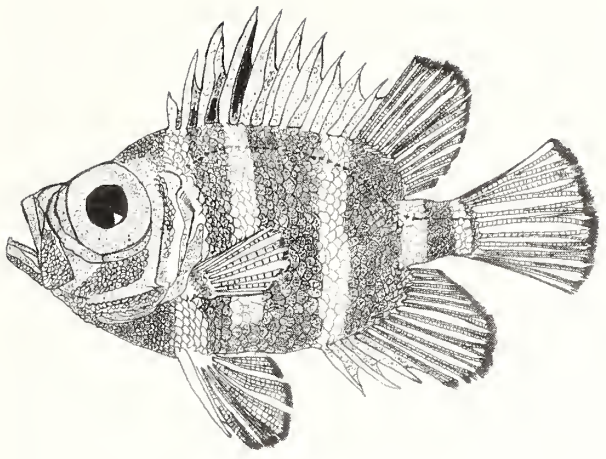

Fig. 1: *Pristigenys niphonia* (Cuvier & Valenciennes, 1829) 250 mm

anterior and posterior of the caudal peduncle (Fig. 1). Origin of the membranous part of the dorsal, ventral and anal fins pinkish and dusky at posterior. Soft portion of dorsal, ventral and anal fins with black margin and white submarginal band.

**Osteology**: Bones are thick, hard and oily; the cranium is depressed, broad in the posterior part and narrow anteriorly. Neurocranium robust and convex in profile around the extremely large orbital region. A large myodome opening to brain cavity behind orbit, supraoccipital, parietal and epiotic crests prominent. Parietal small and paired articulating anteriorly with occipital. Supraoccipital broad, crest-bearing portion projecting well forward between posterior extensions of frontal and posteriorly to very near foramen magnum. Neural process of the first vertebra fused dorsomedially to form spine-like structure unlike the *Priacanthus* spp. Vertebra 23 (10 trunk + 13 caudal), first one fused to exoccipitals and basioccipital; neural process of the first vertebra fused to foramen magnum in larger specimens. Predorsal bone 1. Parasphenoid thick laterally flattened with ventral groove with centro-lateral ridge, a thick sheet of bone extends dorsally throughout its length, articulates anteriorly with ventral surface of the flattened posterior end of the vomer and ventral surface of the ethmoid cartilage.

Branchiostegal rays six with well-developed scales over most of the length, the first one is rudimentary in the smaller specimen (58 mm TL), four rays associated with anterior ceratohyal remaining two with epihyal. Interhyal of the hyoid arch small, narrow providing hind end attachment to the opercular complex at the inner side of the preopercular angle and lies right angle to the hind end of the epihyal. Epihyal broad anteriorly and narrow posteriorly attached to ceratohyal.

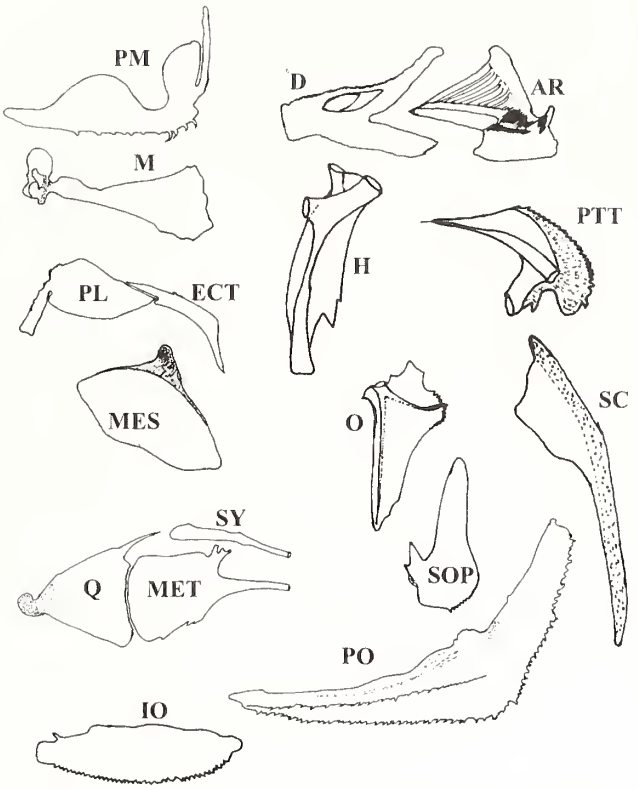


Fig. 2: Lateral view of jaws and parts of opercular series of *P. niphonia*

Ceratohyal narrow anteriorly and broad posteriorly. Urohyal triangular unpaired and broad posteriorly, embedded free in the muscular mass of the throat and connected posteriorly to the rear end of the cleithrum by ligaments (Fig. 3). Preopercle large, crescent-shaped with prominent tripointed spines at postventral angle (Fig. 2).

Palatine with a tooth-bearing shelf ventrolaterally articulating posterioventrally with ectopterygoid; prepalatine with elongate process articulating with maxilla (Fig. 2). Ethmoidal pointed anteriorly and relatively narrow, its lateral flanges folded ventrally, lateral ethmoid with a large foramen. Anterior and posterior lamella of the lateral ethmoid divergent ventrally, straddling on palatine, articulating with frontal, parasphenoid and vomer. Vomerine articulation with lateral ethmoid narrow bearing a foramen medially. Premaxilla with well-developed ascending process and an expansive and complex process articulating with maxilla alveolar ramus with large dorsal flange centrally. Dentary large; paired posteriorly forked bearing small conical teeth, not in rows on dorsal arm (Fig. 2). Articular more or less spear-shaped with thick basal part, a sail-like broad anterior part which fits into the socket of the dentary. Broad metapterigoid articulating anteriorly with quadrate, anterodorsally with ectopterygoid ventrally with rod-like symplectic (Fig. 2).

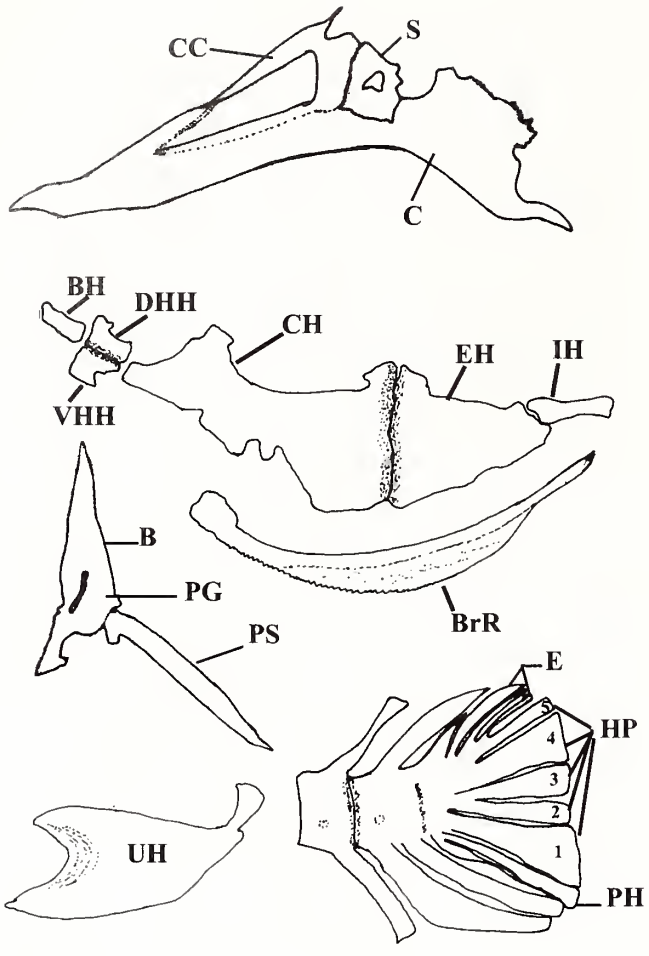


Fig. 3: Lateral view of pectoral girdle, hyoid series, pelvic girdle, urohyal and caudal skeletal of *P. niphonia* (250 mm TL)

Sphenoticum angulate, deflected ventrally behind orbit and moderately produced posteriorly. Epiotic more or less circular in shape, paired and being roof of the auditory capsule articulating with parietals pterotic and occipitals. The middle region of the bony ridge of the epiotic crest drawn into posteriorly directed spine. Pectoral girdle with cleithrum elongate and little curved (Fig. 3).

Pectoral girdle consists of cleithrum, scapula and coracoid. Cleithrum paired and bent, and this is the largest bone of pectoral girdle (Fig. 3). Scapula paired quadrangular bone and it is pierced by a foramen. Coracoid paired, dorsal portion is broad and ventral portion is rod-like. The pelvic girdle includes Basipterygium, which is embedded freely in the flesh of the abdominal wall (Fig. 3). Anal spine 3; Pterigophore 2; first two spines articulated with a single pterigophore. Caudal fin 16, caudal with three epurals, five hypurals and a single parahypural with a large hypurapophysis (Fig. 3).

**Discussion**

*Pristigenys niphonia* occurred rarely in our trawl samplings because of the inaccessibility to the gear, as this species lived near or beneath ledges and crevices of rocky grounds (Starnes 1988), which are untrawlable. This may be the reason for the absence of this species in earlier records. However, the species was recorded in four hauls during the past three years from the same or nearby area (8° 37' N; 76° 14' E).

Boulenger (1895) and Fowler (1931) described *Pristigenys niphonia* with 11-12 dorsal fin rays, while Smith (1966) observed only 11 which agree with the present findings. Based on the reports of Caldwell (1962) and Yoshino and Iwai (1973), it is expected that *P. niphonia* with 12 dorsal fin and 11 anal soft rays is very rare. The Ll. varied between 34-40 (Boulenger 1895; Fowler 1931), 37-43 (Starnes 1988), 35-38 (Smith 1966) which overlap 36-37 recorded in the present study. A significant variation observed in gill rakers count of the specimen collected from Japan waters as 17 (Boulenger 1895) to 30 (Fowler 1931); it varied between

**Table 1**: Proportions of morphometric data of *Pristigenys niphonia* (N=9)

| Morphometric Characters | Proportions | |
|---|---|---|
| | Mean | ± SD |
| Total Length / standard Length | 1.21 | 0.13 |
| Standard length / pre pectoral | 2.31 | 0.18 |
| Standard length / pre pelvic | 2.31 | 0.16 |
| Standard length / pre anal | 1.47 | 0.17 |
| Standard length / pre dorsal | 2.90 | 0.22 |
| Standard length / dorsal fin | 1.88 | 0.13 |
| Standard length / anal fin | 4.19 | 0.10 |
| Standard length / first dorsal fin length | 14.72 | 0.24 |
| Standard length / length of 10th dorsal fin | 6.11 | 0.40 |
| Standard length / length of 5th dorsal fin | 4.16 | 0.39 |
| Standard length / soft dorsal height | 6.89 | 0.72 |
| Standard length / pectoral height | 4.88 | 0.37 |
| Standard length / Pelvic height | 3.55 | 0.72 |
| Standard length / anal height | 4.61 | 0.24 |
| Standard length / head length | 2.49 | 0.02 |
| Standard length / eye diameter | 5.18 | 0.14 |
| Standard length / post orbital | 8.86 | 0.10 |
| Standard length / preorbital | 13.64 | 2.81 |
| Standard length / interorbital | 9.76 | 0.24 |
| Standard length / body depth | 2.01 | 0.18 |
| Head length / eye diameter | 2.08 | 0.13 |
| Head length / post orbital | 3.55 | 0.14 |
| Head length / preorbital | 5.47 | 1.16 |
| Head length / interorbital | 3.91 | 0.27 |

**Table 2**: Comparison of descriptions from different areas

| Descriptions | Fowler, 1931 Japan | Boulenger, 1895 Japan | Smith, 1966 | Starnes, 1988 W. Indian Ocean | Present report |
|---|---|---|---|---|---|
| Indo-Pacific | | | | | |
| Dorsal fin | X, 11-12 | X, 11-12 | X, 11 | X, 10-12 | X, 11 |
| Anal Fin | III, 10 | III, 10 | III, 10 | III, 10 | III, 10 |
| Ll. scales | 34-40 | 34-40 | 35-38 | 37-43 | 34-37 |
| Gill Rackers | 9 + 21 | 17 | 14-26 | 27-29 | 5-7 +17-19 22-26 |
| Head length in Standard length | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Body depth in Standard length | 1.8 | 2 | 1.9-2.0 | 1.9 | 1.9-2.09 |

24 and 26 (Smith 1966, western Indian Ocean) and 22-24 (present record). Three light bars observed on the body of the specimens collected from South Africa (Smith 1966), 4-5 bars from Indo-Pacific region (Starnes 1988) and five bars in the present observation. Starnes (1988) recorded specimens of 270 mm with 40-50 spinules of mid-lateral scales and also suggested that this may be fewer in smaller specimens, the present specimen has 27-37 spinules.

The pertinent records on the occurrence of this species are along coast of East Africa and along the extensive mid Indian Ocean ridge that includes Socotra, Chagos, Rodrigues and St. Paul, possible north to Maldives, Sri Lanka, however, according to FAO records it is questionable in India. Computation of some body parts (Body depth, head length, height of dorsal fin, pectoral fin, ventral fin) in standard length and others (Eye diameter, upper jaw length, dorsal spine length, pectoral fin length, ventral fin length) in head length (Table 1) of the present specimens are very close to *P. niphonia* collected by Smith (1966) from south Africa (Table 2), which supports the theory of common geographical distribution of marine ichthyofauna of India and Africa, perhaps the distribution of this species has extended to the northern latitudes in the Indian Ocean.

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## 10. FISH DIVERSITY IN ACHENKOVIL RIVER, KERALA, INDIA

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### Introduction

Western Ghats, located along the south-west coastline of the Indian subcontinent is extremely rich in its fish diversity and endemicity (Gopalakrishnan and Ponniah 2000). The perennial river, Achenkovil flows through the central Travancore region in Kerala state and rises south of Devarmalai in the Western Ghats at an elevation of about 700 m. The river in its course is joined by a number of tributaries such as Kanai Ar, Kall Ar, Chittar, Kakkad Ar. The river has an average flow of about 2,287 $Mm^3$ and ultimately drains into the Vembanadu lake system.

Despite the occurrence of a large number of studies on the riverine fish fauna in Kerala (Biju *et al.* 1998, 1999a, b; Johnson and Soranam 2001; Kumar and Sushama 2001; Sushama 2003), there was paucity on the documentation of fish species and their distribution in Achenkovil river. Hence, the present study was undertaken to collect data on species richness and distribution of ichthyofauna in Achenkovil river basin.

Fig. 1: Map showing the sampling stations in Achenkovil River Basin, Kerala

**Table 1**: Distribution of fish fauna in Achenkovil river collected during 2004-2005

| S.No. | Order/ Family | Species | Stations | | | |
|---|---|---|---|---|---|---|
| | | | I | II | III | IV |
| | Order: Clupeiformes | | | | | |
| 1 | Family: Clupeidae | *Dayella malabarica* (Day) | - | + | + | + |
| | Order: Cypriniformes | | | | | |
| 2 | Family: Cyprinidae | *Amblypharyngodon melettinus* (Valenciennes) | + | + | + | + |
| 3 | | *Amblypharyngodon microlepis* (Bleeker) | + | + | + | + |
| 4 | | *Barilius bakeri* (Day) | + | + | + | + |
| 5 | | *Barilius gatensis* (Valenciennes) | + | + | + | + |
| 6 | | *Catla catla* (Hamilton-Buchanan) | - | + | + | - |
| 7 | | *Cyprinus carpio* (Linnaeus ) | - | + | + | - |
| 8 | | *Danio malabaricus* (Jerdon) | + | + | + | + |
| 9 | | *Garra mullya* (Sykes) | + | + | + | + |
| 10 | | *Gonoproktopterus dubius* (Day) | - | + | + | - |
| 11 | | *Labeo dussumieri* (Valenciennes) | - | + | + | - |
| 12 | | *Labeo rohita* (Hamilton-Buchanan) | - | - | + | + |
| 13 | | *Osteobrama bakeri* (Day) | - | - | + | - |
| 14 | | *Parluciosoma daniconius* (Hamilton-Buchanan) | + | + | + | + |
| 15 | | *Puntius amphibius* (Valenciennes) | + | + | + | + |
| 16 | | *Puntius chola* (Hamilton-Buchanan) | - | - | + | + |
| 17 | | *Puntius denisonii* (Day) | + | - | + | + |
| 18 | | *Puntius fasciatus* (Day) | + | + | + | + |
| 19 | | *Puntius filamentosus* (Valenciennes) | + | + | + | + |
| 20 | | *Puntius jerdoni* (Day) | - | + | - | - |
| 21 | | *Puntius sarana subnasutus* (Valenciennes) | - | + | - | + |
| 22 | | *Salmostoma boopis* (Day) | + | + | + | + |
| 23 | Family: Balitoridae | *Balitora mysorensis* (Hora) | + | + | - | - |
| 24 | | *Nemacheilus guentheri* (Day) | + | + | + | - |
| 25 | | *Nemacheilus triangularis* (Day) | + | - | - | + |
| 26 | Family: Cobitidae | *Lepidocephalus thermalis* (Valenciennes) | + | - | - | - |
| | Order: Siluriformes | | | | | |
| 27 | Family: Bagridae | *Horabagrus brachysoma* (Gunther) | - | - | - | + |
| 28 | | *Mystus gulio* (Hamilton-Buchanan) | - | + | + | - |
| 29 | | *Mystus keletius* (Valenciennes) | - | - | + | + |
| 30 | | *Mystus malabaricus* (Jerdon) | + | + | + | + |
| 31 | | *Mystus menoda* (Hamilton-Buchanan) | - | + | - | - |
| 32 | | *Mystus oculatus* (Valenciennes) | + | - | + | + |
| 33 | Family: Siluridae | *Ompok bimaculatus* (Bloch) | - | - | + | + |
| 34 | | *Ompok malabarius* (Valenciennes) | - | - | + | + |
| 35 | Family: Sisoridae | *Glyptothorax housei* (Herre) | + | - | - | - |
| | Order: Cyprinodontiformes | | | | | |
| 36 | Family: Hemiramphidae | *Hyporhamphus limbatus* (Valenciennes) | - | - | + | + |
| 37 | Family: Belonidae | *Xenentodon cancila* (Hamilton-Buchanan) | - | + | + | + |
| 38 | Family: Aplocheilidae | *Aplocheilus lineatus* (Valenciennes) | + | + | - | + |
| | Order: Perciformes | | | | | |
| 39 | Family: Ambassidae | *Chanda nama* (Hamilton-Buchanan) | - | + | + | + |
| 40 | | *Parambassis thomassi* (Day) | - | + | + | + |
| 41 | Family: Gerreidae | *Gerres filamentosus* (Cuvier) | - | - | - | + |
| 42 | Family: Nandidae | *Nandus nandus* (Hamilton-Buchanan) | - | - | + | + |
| 43 | | *Pristolepis marginata* (Jerdon) | - | + | + | - |
| 44 | Family: Cichlidae | *Etroplus maculatus* (Bloch) | + | + | + | + |
| 45 | | *Etroplus suratensis* (Bloch) | - | + | + | + |
| 46 | | *Oreochromis mossambicus* (Peters) | - | - | - | + |
| 47 | Family: Gobiidae | *Awaous gutum* (Hamilton-Buchanan) | - | - | - | + |
| 48 | Family: Anabantidae | *Anabas testudineus* (Bloch) | + | - | - | + |
| 49 | Family: Channidae | *Channa marulius* (Hamilton-Buchanan) | - | - | + | + |
| 50 | | *Channa punctatus* (Bloch) | - | - | + | - |
| 51 | | *Channa striatus* (Bloch) | - | - | + | - |
| 52 | Family: Mastacembelidae | *Mastacembelus armatus* (Lecepede) | - | - | - | + |

+: presence; -: absence

**Functional group assignation according to Talwar and Jhingran (1991)**

**Material and Methods**

Fish were collected from four different stations, namely Thura, Konni, Pandalam and Payipad along the course of Achenkovil river from February 2004 to January 2005 (Fig. 1). The gears used were cast net and gill net. Catches from two types of gear were combined and fixed in 5% formaldehyde solution. All fish were identified using standard keys (Talwar and Jhingran 1991; Jayaram 1999).

**Results and Discussion**

In the present study, among the 52 species of fishes recorded and identified (Table 1), 39 species were typically freshwater fauna and 3 were typically marine fauna. Fish species those are able to inhabit both in estuarine and riverine habitat were also observed. Species such as *Barilius bakeri*, *Osteobrama bakeri*, *Horabagrus brachysoma*, *Glyptothorax housei*, *Pristolepis marginata* and *Dayella malabarica* were endemic to Kerala. While assessing the status of fish species as per IUCN, under the threatened category, *Dayella malabarica* and *Ompok malabarius* were critically endangered while *Gonoproktopterus dubius*, *Labeo dussumieri*, *Puntius denisonii*, *Horabagrus brachysoma*, *Mystus malabaricus*, *Mystus oculatus* and *Glyptothorax housei* were endangered, *Catla catla*, *Puntius jerdoni*, *P. chola*, *Puntius sarana subnasutus*, *Nemacheilus guentheri*, *Ompok bimaculatus*, *Nandus nandus* and *Pristolepis marginata* were vulnerable. The composition and abundance of fish species varied between the sampling sites. Smaller cyprinids such as *Puntius fasciatus*, *Nemacheilus triangularis* and *Puntius denisonii* were common in the upstream sampling stations like Station 1 and 2. While larger species like *Labeo* sp., *Cyprinus carpio* and *Catla catla* were common in the downstream stations like Stations 3 and 4. When the water level recedes, brackish-water dwelling species like *Xenentodon cancila*, *Etroplus* sp., *Mastacembelus armatus* and *Awaous gutum* also frequently occurred in the downstream stations. Species like *Salmostoma boopis*, *Puntius filamentosus*, *Garra mullya*, *Danio malabaricus* were found to be distributed all along the river system.

Total species richness and abundance was lowest for Station 1. Only twenty-two species from a total of fifty-two were listed. Dominant species observed at this station included *Puntius fasciatus* and *Garra mullya*. Thirty species were recorded from Station 2. Maximum abundance was shown by *Salmostoma boopis*. Maximum species occurrence (thirty-eight) was seen at Station 3. Species such as *Puntius amphibius* and *P. filamentosus* occurred in higher density. The availability of different habitat types might attribute to an increase in species composition at this station. Thirty-seven species were recorded from Station 4. Maximum abundance was recorded for *Puntius amphibius* and *P. filamentosus*. Similarly, marine species like *Parambassis thomasii* were also found to be high. Habitat preference and adequate environmental conditions made this station a fish abundant area.

From the studies, it is clear that River Achenkovil is rich in terms of diversity and abundance of fish fauna. However, in the light of arising habitat destruction process such as sand mining day by day, proper management measures must be adopted to protect the existing faunal wealth.

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# 11. NEW RECORDS OF FIVE SPECIES OF COLONIAL ASCIDIANS OF THE GENUS *ECTEINASCIDIA* HERDMAN, 1880, FROM THE GULF OF MANNAR, INDIA

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## Introduction

So far, only six species of colonial ascidians of the genus *Ecteinascidia* – *E. bombayensis* Das, 1938; *E. garstangi* Sluiter, 1898; *E. imperfecta* Tokioka, 1950; *E. krishnani* Renganathan & Krishnaswamy, 1985; *E. venui* Meenakshi, 2000; *E. sluiteri* Herdman, 1906, have been reported from India by earlier workers (Das 1938; Renganathan 1984, 1986; Renganathan and Krishnaswamy 1985; Meenakshi 2000; Meenakshi and Venugopal 2000). The present paper reports five more species, *E. diaphanis* Sluiter, 1885; *E. diligens* Sluiter, 1900; *E. koumaci* Monniot, 1987; *E. nexa* Sluiter, 1904 and *E. styeloids* Traustedt, 1882, for the first time from the Gulf of Mannar.

### *Ecteinascidia diaphanis* Sluiter, 1885

**Occurrence and distribution**: The colony was collected from the intertidal rocky shore of Ervadi, (9° 11' N; 78° 43' E) Tamil Nadu, south-east coast of India, seen attached to the undersurface of rocks. Only a few zooids were intact. This species has been previously reported from Australia, Palau Islands and Indonesia.

**Synonymy**: *Ecteinascidia diaphanis* Sluiter, 1885, p. 168. Beneden, 1887, p. 28. Sluiter, 1904, p. 10. Tokioka, 1950, p. 127. Kott, 1964, p. 145. Kott, 1966, p. 292. Kott, 1985, p. 90.

**External appearance**: Individuals are small – 0.75-1 cm, upright, cylindrical tapering to a stalk posteriorly. There is a common basal stolon mass attached to the substratum to which the short posterior stalk is connected. The test is thin and transparent. The apertures are on short conical projections on opposite sides of the upper surface. Both the apertures have six lobes. The main test vessel leaves the body from the posterior end of the endostyle. Vascularisation of the test inconspicuous. Living specimens are light pinkish orange with a reddish orange band around the rim of apertures and base of siphons; the colour fades on preservation.

**Internal appearance**: Body wall thin and transparent with a fine network of muscles in the anterior half. Circular and longitudinal muscles are present in the siphons. Transverse muscles are not present between siphons, but posterior to the atrial siphon, a wide band of 35-40 fine parallel

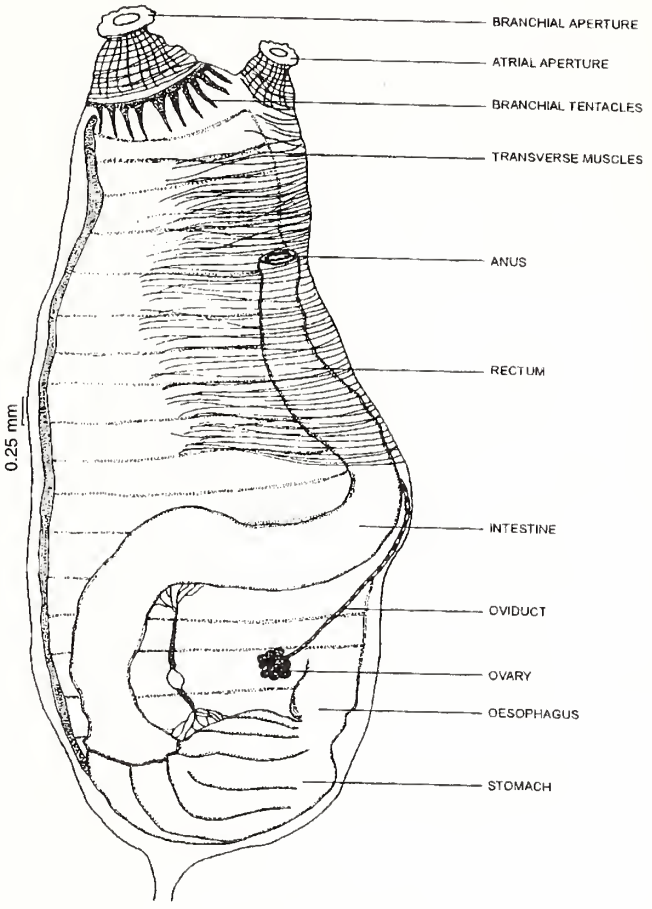


Fig. 1: *Ecteinascidia diaphanis*: Zooid from left side showing gut loop, ovary and muscles

muscles are present, which extends only three-fourths of the body on the right and half of the body on the left. Transverse muscles absent from the ventral half of the body (Fig. 1). The dorsal tubercle has a two-lipped opening. The dorsal lamina has long pointed transversely flattened languets without an upright membrane between them. The branchial sac has 16 rows, each row with about 45-50 stigmata. About 15 internal longitudinal vessels are present on each side with small rounded papillae at their junction with the transverse vessels. There are 3-4 stigmata per mesh. Oesophageal opening at the posterior end of the branchial sac. Oesophagus short, stomach large, rectangular with 5 spiral ridges. The mid-intestine

curves anteriorly and the intestine forms a wide curve towards the mid-dorsal border. Rectum extends anteriorly. There is a gastro-intestinal connective from the distal end of the stomach, which breaks up into many branches along the inner curve of the intestine. Gonads situated in the gut loop. Only ovary was found in the zooids examined. Larvae were not observed.

**Remarks**: This species is being reported for the first time in Indian waters. The present species can be identified by their transparent test, posterior position of stalk, wide band of transverse muscles behind the atrial siphon, absence of transverse muscles from the ventral half of the body, apertures on the upper surface on short conical projections, and transversely flattened languets. The present specimens have 16 rows of stigmata resembling Tokioka's specimens from Palau Islands, but differ from Kott's specimen from New South Wales which has 18-19 rows.

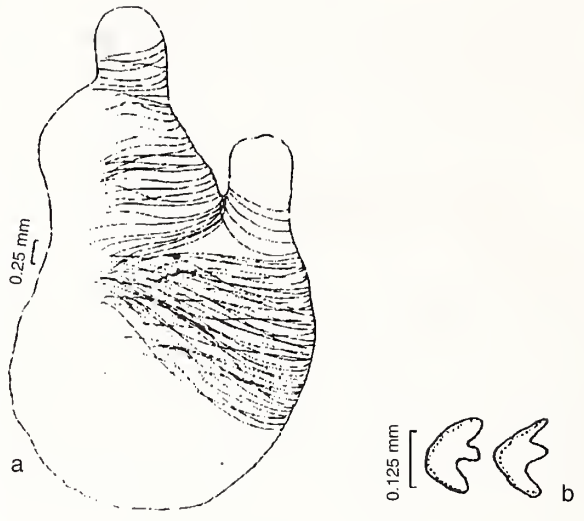


Fig. 2 (a-b): *Ecteinascidia diligens*:
a. Zooid from left side showing musculature;
b: branchial papillae

*Ecteinascidia diligens* Sluiter, 1900

**Occurrence and distribution**: Many colonies were collected from the littoral zone of Mandapam (9° 16' N; 79° 8' E), attached to the undersurface of calcrete rocks. This species has been previously reported from Philippines.

**Synonymy**: *Ecteinascidia diligens* Sluiter, 1900, p. 110.

**External appearance**: The colony consists of a crowded mass of zooids, a few of them fused along their sides to the adjacent zooid. A short stalk from the posterior ventral end of the body connects the zooids to a basal mass of stolon network. Largest zooid 9 mm high and 6 mm broad and the smallest one 6 mm x 4 mm. Posterior end of the body rounded. The test is thin, glassy and vascularised. Mud, sand, shell pieces and other epibionts were attached to it. In life, the zooids are reddish brown, but the colour was lost on preservation. The apertures are sessile in individuals with test, but when the test is removed siphons are visible as short cylindrical structures. Branchial aperture terminal with 7-9 small broad lobes, atrial aperture one-third of the distance along the dorsal surface with 6-9 small lobes.

**Internal structure**: Body wall thin, transparent with conspicuous network of blood vessels and yellowish brown pigments in life. Circular and longitudinal muscles are present in the siphons. Transverse muscles are present between the siphons and below the atrial aperture as parallel bands extending only three-fourths on the right side and halfway on the left side (Fig. 2a). About 40 branchial tentacles of two orders – long and medium – alternate with each other. Prebranchial area wide. Dorsal tubercle an oval cushion with a narrow inconspicuous slit. The dorsal lamina is inconspicuous and languets were not observed. The branchial sac has 11 rows, each with 35-40 stigmata. 8-12 internal longitudinal vessels are present on each side which are interrupted in many regions where the papillae are bifid (Fig. 2b). At other regions, the papillae are large and rounded. There are 3-4 stigmata between two papillae. Oesophagus at the posterior end of the branchial sac. The stomach is slightly elongate, smooth. Posterior stomach, mid-intestine not distinct (Fig. 2c). The anterior margin of the primary gut loop is in level with the anus present at the level of the 7$^{th}$ transverse vessel. The primary gut loop is deep with an open pole. The secondary gut loop is also deep and the axis passes through the oesophagus. Rectum fairly long on the mid-dorsal line.

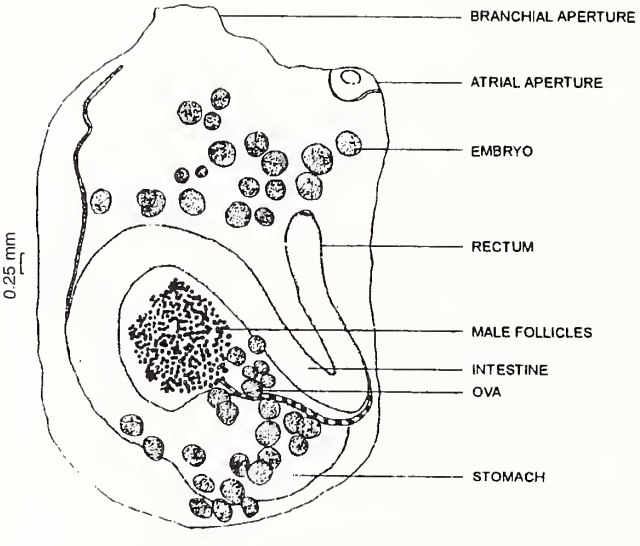


Fig. 2c: *Ecteinascidia diligens*: Zooid from left side showing gut loop, gonads and embryos packed in the peribranchial cavity

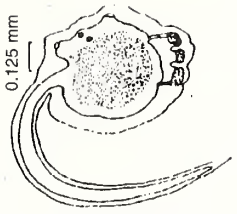


Fig. 2d: *Ecteinascidia diligens*: Larva

Anus with smooth border. Gastro-intestinal duct was not observed. The gonads consist of the testis follicles in the form of a bunch, occupying a major portion of the primary gut loop with a distinct vas deferens. 3-10 large ova situated in front of the testis follicles. About 54 embryos in various stages of development were present in the right peribranchial cavity. The larval trunk measures 0.5 to 0.6 mm with an otolith and ocellus. The adhesive organs are unstalked, present in the median vertical line. The tail extends more than halfway (Fig. 2d).

**Remarks**: The characters distinguishing the species are their colour (reddish brown in living colonies), parallel transverse muscles, between the siphons and posterior to the atrial siphon, primitive nature of the dorsal lamina, interrupted internal longitudinal vessels with bifid papilla, smooth stomach, anus, testis follicles behind the ovary, right peribranchial cavity packed with developing embryos and the larval trunk measuring only 0.5 to 0.6 mm.

The specimen studied has been deposited in the National Collections of the Zoological Survey of India, Chennai (Reg. No. AS. 18).

### *Ecteinascidia koumaci* Monniot, 1987

**Occurrence and distribution**: Many colonies were seen attached to the undersurface of rocks in the littoral zone of Mandapam. This species has been previously reported from New Caledonia.

**Synonymy**: *Ecteinascidia koumaci* Monniot, 1987, p. 28.

**External appearance**: The colonies consist of large individuals, upright and cylindrical, 1 cm x 0.5 cm and smaller ones measuring 6 mm x 3 mm, attached to a basal mat of stolon by a short stalk from the postero-ventral corner of the zooid. The basal stolon has many small buds. The test is transparent, glassy and the mustard coloured gut and gonads can be clearly seen through the test in live specimens. Epibionts, sand and algal filaments were found attached to the test in a few zooids. The apertures are on conspicuous cylindrical siphons, the branchial aperture terminal with 6 lobes and the atrial aperture antero-dorsal with 6 lobes. The posterior end of the zooid may be rounded or tapering to a stalk in a few zooids. The test is vascularised.

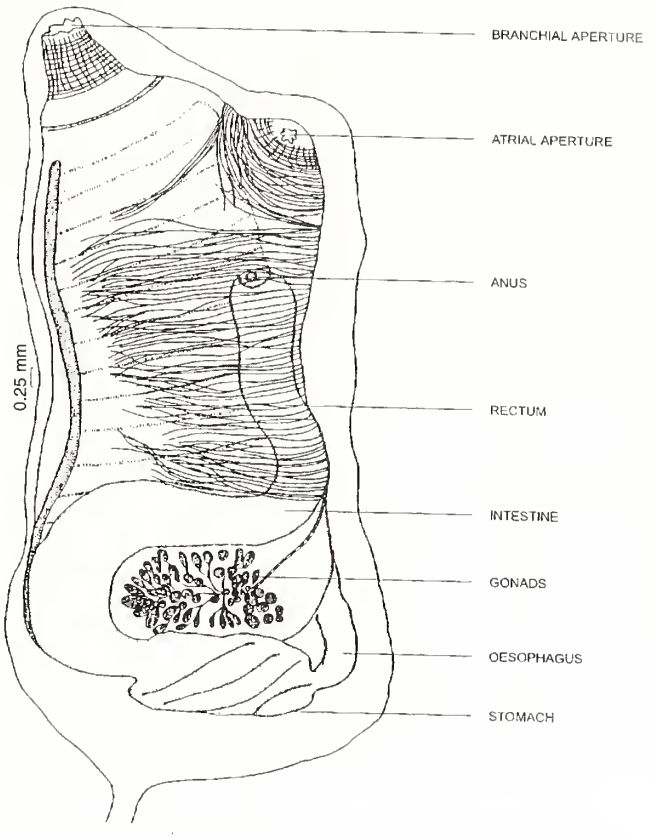


Fig. 3: *Ecteinascidia koumaci*: Zooid from left side showing gut loop, gonads and muscles

**Internal structure**: The body wall is thin and transparent. Circular muscles and short longitudinal muscles are present only in the siphons (Fig. 3). There are around 40-45 transverse muscles running parallel to each other extending only three-fourth of the sides of the body. There are 3-4 transverse muscles between the siphons. These muscles proceed towards the transverse muscles situated posterior to the atrial siphon and usually merge with them. More than 40 tentacles of two different sizes – medium and long. The dorsal tubercle is an elongated cushion with a simple opening. The dorsal lamina has large triangular languets laterally flattened, situated at places where the transverse vessel crosses the branchial sac with a membrane connecting them. The free ends of the languets are curved to the right. The pre-pharyngeal groove has no outgrowth. Branchial sac has 15 rows with 30 elongate stigmata in each half. 2-3 stigmata in a mesh. 13 internal longitudinal vessels, not interrupted. On either sides of the dorsal lamina internal longitudinal vessels are absent but are represented by small papillae. Branchial papillae inconspicuous. Primary gut loop wide. The axis of the secondary loop passes in front of the

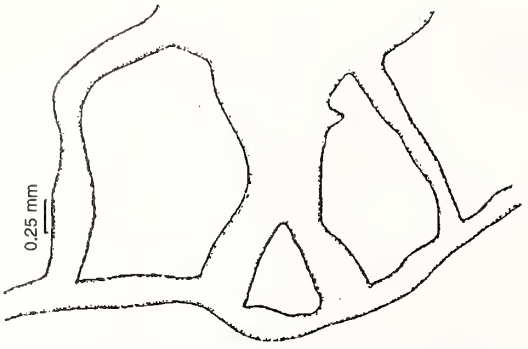


Fig. 4a: *Ecteinascidia nexa*: Accessory connectives from the posterior end of zooid

oesophagus, which is at the posterior end of the branchial sac. Stomach more or less rectangular and ridged. A constriction is present between the mid-gut and intestine. No intestinal pouches. Rectum is short. Anterior pole of the gut loop at the level of the 11th transverse vessel. A gastro-intestinal duct is present. Gonads consist of a central ovary with 10-12 ova and numerous elongate testis follicles arranged in a semicircle around the ovary. No larva was observed. A brood pouch with eggs observed on the posterior right side of the body.

**Remarks**: The characters used to distinguish the species are the open gut loop, the presence of 3-5 transverse muscles in the inter-siphonal area, membrane between the languets and ridges on the stomach. Most of the characters observed in the present species agree with the description of *Ecteinascidia koumaci* Monniot, 1987. But a few differences, such as size of the zooid, less number of rows of stigmata, less number of internal longitudinal vessels, were observed in the present specimen.

The specimen studied has been deposited in the National Collections of the Zoological Survey of India, Chennai (Reg. No. AS. 15).

***Ecteinascidia nexa*** Sluiter, 1904

**Occurrence and distribution**: Many colonies were seen attached to the undersurface of calcrete stones in the littoral zone of Ervadi. This species has been previously reported from Australia, Indonesia, Fiji, Sri Lanka and Japan.

**Synonymy**: *Ecteinascidia nexa* Sluiter, 1904, p. 11. Herdman, 1906, p. 298. Tokioka, 1954, p. 255. Kott, 1966, p. 292. Kott, 1981, p. 196. Kott, 1985, p. 94.

**External appearance**: Colonies consist of crowded zooids forming extensive mats on the undersurface of stones, rocks, etc. The zooids are transparent or with a light greenish yellow colour. The alimentary canal and gonads are mustard yellow. Zooids are prostrate or upright, 4-5 mm long and 2-3 mm wide, attached by a short horny stalk from the posterior end of the ventral surface to a basal mass of stolons. In a few zooids, the stalk was found to arise from about the middle of the ventral surface. Accessory test connectives were observed only in a few zooids (Fig. 4a). The test is vascularised, thin, transparent, delicate and naked. The apertures are on short conical siphons, branchial aperture terminal with 8 lobes and atrial aperture 6-lobed halfway along the dorsal surface. The posterior end of the zooid is rounded and the zooid as a whole is egg-shaped.

**Internal structure**: Body wall is thin, delicate, vascularised and reddish brown after preservation. Circular muscles are present around the siphons, longitudinal muscles do not extend beyond the siphons, transverse muscles about 12-15 present between siphons and 16-20 posterior to the atrial siphon (Fig. 4b). These muscles extend almost the whole of the right side of the body, but only three-fourths on the left side. The dorsal tubercle is an oval cushion with a simple opening. The dorsal lamina has transversely flattened languets with a low basal membrane between them. The main test vessel originates from the body wall one-third to one-half the distance from the posterior end of the body. There are 12-15 rows of stigmata with 40-45 stigmata on each side. About 13 internal longitudinal vessels are present with 2-3 stigmata in each mesh. A few internal longitudinal vessels near the dorsal lamina are interrupted. Short rounded branchial papillae are present. There are about 30-45 branchial tentacles of two sizes – medium and long. The gut loop occupies the posterior half of the body. The primary gut loop is deep,

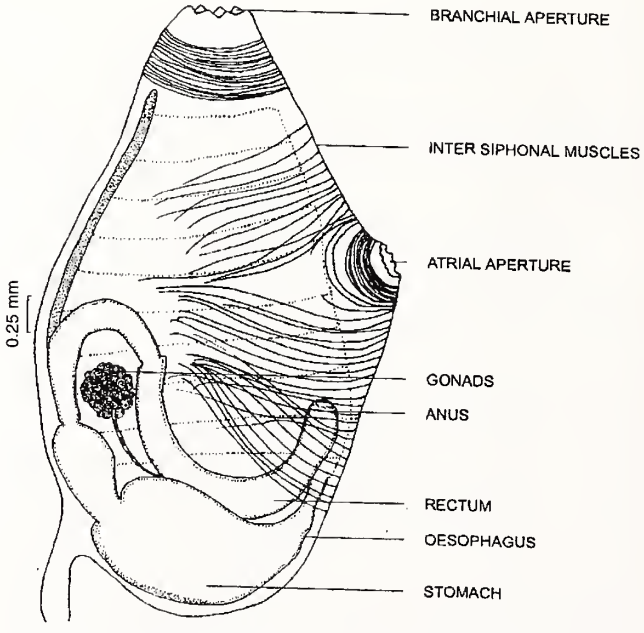


Fig. 4b: *Ecteinascidia nexa*: Zooid from left side

slightly open at the pole. The rectum forms a deep secondary loop with the descending limb of the intestine. The axis of the secondary gut loop passes through the middle of the stomach. Oesophagus is curved, situated at the posterior end of the branchial sac. The stomach is slightly elongate, horizontal without any ridges. A small posterior stomach is present. The mid-intestine is wide and there is a constriction between the mid-intestine and the narrow duodenal area. The rectum is short. The anterior pole of the gut loop is at the level of the 5th transverse vessel and the anus is smooth and situated at the level of the 8th transverse vessel. A gastro-intestinal duct is present. Gonads enclosed in the gut loop. The ovary is very small, situated in the centre of a circle of male follicles. Larvae were not observed.

**Remarks**: The characters mentioned by earlier workers were also observable in this Indian specimen. The important characters are the large carpet-like colonies, small prostrate zooids, position of atrial aperture, cloudy body wall, deep secondary gut loop and large smooth stomach.

The specimen studied has been deposited in the National Collections of the Zoological Survey of India, Chennai (Reg. No. AS. 14).

*Ecteinascidia styeloids* Traustedt, 1882

**Occurrence and distribution**: A few zooids were collected in June, 1993 from the intertidal rocky shores of Ervadi. This species has been previously reported from France.

**Synonymy**: *Ecteinascidia styeloids* Traustedt, 1882, p. 277. Van Name, 1921, p. 391. Van Name, 1930, p. 470. Monniot, 1983, p. 59.

**External appearance**: Zooids upright and sub-cylindrical, measuring 5-7 mm high. The test is delicate and transparent, with a network of blood vessels. The apertures are on long cylindrical siphons. The branchial aperture is terminal with 6 small inconspicuous lobes. Atrial aperture at the level of 4-5th row of gill slit and with 6 broad lobes. Body is rounded posteriorly and a stalk is present at the postero-ventral side attached to a sponge. The test is naked and the living colony has a slight red colour. The main test vessel arises from the posterior ventral end of endostyle.

**Internal structure**: Body wall is thin, transparent, circular and longitudinal muscles are present in the siphons. The transverse muscles include 25 intersiphonal muscles and 40-45 transverse muscles below the atrial siphon, which extend to about three-fourths of the body on both sides (Fig. 5). The dorsal tubercle is small, oval with a slit-like opening. The dorsal lamina has tongue-shaped transversely flattened languets. The branchial tentacles are of two sizes, very long and medium, about 50-60. The branchial sac has

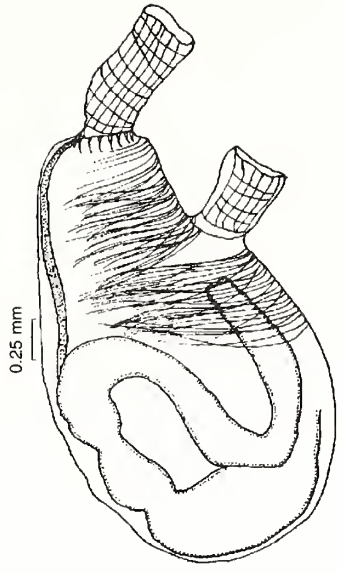


Fig. 5: *Ecteinascidia styeloids*: Zooid from left side showing gut loop and musculature

13 rows of about 20 stigmata in each row. There are 14 internal longitudinal vessels and 1-1½ stigmata per mesh. Branchial papillae are present at the junction of the internal longitudinal vessels. Transverse vessels are small and rounded. The gut forms a deep primary and secondary loop. Oesophagus is at the posterior end of the branchial sac. Stomach is smooth, rounded, lying horizontally. There is a constriction between the posterior stomach, mid-intestine and intestine. The axis of the primary gut loop is at the level of the 5th transverse vessel. The axis of the secondary gut loop passes through the posterior end of the stomach. The rectum is long and the smooth anus lies very near to the 4th transverse vessel. Gastro-intestinal duct not observed. Gonads were not present in the few zooids studied.

**Remarks**: This species is being reported for the first time from Indian waters. The characters by which this species can be identified are the long cylindrical siphons, inter siphonal muscles, deep primary and secondary gut loop and rounded smooth stomach.

The specimen studied has been deposited in the National Collections of the Zoological Survey of India, Chennai (Reg. No. AS. 17).

KEY TO THE SPECIES OF *ECTEINASCIDIA* RECORDED FROM INDIA

1. Both apertures on or near the anterior end of the body, no transverse muscles between apertures ..... 2
— Atrial aperture dorsal, branchial aperture terminal, transverse muscles between atrial and branchial apertures ..... 4
2. Transverse muscles in 3 longitudinal bands ..... *E. sluiteri*
— Transverse muscles not in 3 longitudinal bands ..... 3

3. Almost sessile apertures, transversely flattened languets ..... *E. diaphanis*
— Short cylindrical siphons, laterally flattened languets with a membrane between them ..... *E. venui*
4. Only 3-5 transverse muscles between siphons .. *E. koumaci*
— More than 3-5 transverse muscles between siphons ..... 5
5. Meshwork of muscles on the right side of the body ..... *E. imperfecta*
— No meshwork of muscles on the right side of the body .... 6
6. 11 rows of stigmata ..... *E. diligens*
— More than 11 rows of stigmata ..... 7
7. Anterior border of gut loop level with the anus ..... *E. krishnani*
— Anterior border of gut loop not level with the anus ..... 8
8. Stomach with longitudinal folds ..... *E. bombayensis*
— Stomach without longitudinal folds ..... 9
9. With conspicuous siphons ..... *E. styeloids*
— Without conspicuous siphons ..... 10
10. Large carpet-like colonies with prostrate zooids, cloudy body wall, large spherical smooth stomach ..... *E. nexa*
— Colonies not crowded, erect zooids, body wall not cloudy, small oval smooth stomach ..... *E. garstangi*

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# 12. BIODIVERSITY OF WILD SILK MOTHS IN NAGALAND

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## Introduction

Wild silk moths are a relatively well-known group of insect fauna of Family Saturniidae. They are admired by people throughout the world (Peigler 1996). A good number of references are available on seribiodiversity and its potential as the source of natural silk in the Indian subcontinent,

extending from the sub Himalayan to Sri Lankan region (Arora and Gupta 1979; Thangavelu 1991; Nassig *et al.* 1996; Chinnaswamy 2001; Thangavelu *et al.* 2002; Srivastava and Thangavelu 2005). North-eastern India is the centre of wild silk culture and several kinds, including muga, eri, tropical tasar, temperate tasar and fagara silks are produced here (Peigler and Naumann 2003). However, biodiversity of silk moths in the wild of North-eastern India is not yet fully understood as their distribution is restricted to highly inaccessible areas. While some stray reports on the exploration of wild sericigenous or silk producing insects from north-eastern region are available (Thangavelu and Borah 1986; Thangavelu *et al.* 1987; Bhattacharya *et al.* 2004), information on the biodiversity and distribution of wild silk moths in Nagaland is not available.

Nagaland, one of the north-eastern states of India, is situated in the trans-Himalayan region between 25° 26'-27° 40' N and 93° 20'-95° 15' E. The topography of Nagaland is characterised by hills and mountains, and deep gorges and steep slopes. The altitude of the area varies from 199 m to 3,841 m. Nagaland state, like Manipur, is the meeting place of the Siberian and Manchuria sub-regions of the Palaearctic Region, and the Indo-Chinese and Indian sub-regions of the Oriental Region. Nagaland has rich forest resources with forests covering over 85.43% of the total land surface. Humid mesothermal warm temperate with dry winter Gangetic type climate prevails in the state. The average annual rainfall is 2,584.5 mm having wet season from May to October. The temperature ranges from 12 °C to 32 °C in summer and 5 °C to 20 °C in winter, and the average relative humidity varies from 67% (March) to 88% (October).

**Table 1**: Wild silk moths of Family Saturniidae in Nagaland

| Common name | Scientific Name |
|---|---|
| Muga silk moth | *Antheraea assamensis* (Helfer) |
| Oak tasar silk moth | *Antheraea roylei* (Moore) |
| Oak tasar silk moth | *Antheraea proylei* (Jolly) |
| Oak tasar silk moth | *Antheraea frithii* (Moore) |
| Indian moon moth | *Actias selene* (Hubner) |
| — | *Actias rhodopneuma* (Rober) |
| Atlas moth | *Attacus atlas* (Linnaeus) |
| — | *Archaeoattacus edwardsii* (White) |
| — | *Cricula trifenestrata* (Helfer) |
| Wild eri moth | *Samia canningi* (Hutton) |
| Indian eri moth | *Samia ricini* (Donovan) |
| — | *Sonthonnaxia maenas* (Doubleday) |
| — | *Loepa katinka* (Westwood) |
| — | *Loepa sikkima* (Moore) |

A recent review of the species composition of India listed 47 species of wild silk moths (Singh and Suryanarayana 2005) of which 24 species (Singh and Chakravorty 2006) of Family Saturniidae are found in north-east India. Of these only three species, namely *Antheraea assamensis*, *Antheraea roylei* and *Attacus atlas* have been reported from Nagaland. Hence, an attempt has been made to study wild silk moths, highlighting their bio-ecological characteristics, ecological traits and host plants distribution, in Nagaland.

**Material and Methods**

An extensive survey was carried out in Nagaland during 2004-2005 to collect wild silk moths and record their host plants. Identification of the collected material was made using literature. All the material reported here is in the collection of the Ecology Laboratory, Department of Zoology, Nagaland University, Mokokchung. Description of adult morphological characteristics was limited to those silk moth species for which host plants were not ascertained. However, other species, i.e., *Antheraea assamensis* (commercially reared and wild variety), *A. roylei*, *A. proylei*, *Actias selene*, *C. trifenestrata*, *Samia canningi* and *S. ricini*, were reared on their most suitable host plants at the Ungma sericulture farm, Govt. of Nagaland, to study various parameters like colour, size and weight of different life stages and economic traits.

**Results and Discussion**

Table 1 presents a list of 14 species belonging to 8 genera collected during the survey. Among these only adults of *Antheraea frithi*, *Attacus atlas*, *Archaeoattacus edwardsii*, *Sonthonnaxia maenas*, *Loepa sikkima* and *L. kitinka* were collected without confirmation of their host plants. Both the adult as well as larval stages of the rest of the species, i.e., *Antheraea assamensis*, *A. roylei*, *A. proylei*, *Actias selene*, *C. trifenestrata*, *Samia canningi* and *S. ricini*, with their primary and secondary host plants distributed in different parts of Nagaland, were recorded. The wild variety of *A. assamensis* which is large in size and deeper in colour was also recorded from same areas of Nagaland. It is trivoltine undergoing partial diapause in the pupal stage during winter. Further, worms of wild variety are very much active and strong, and cocoon characters such as colour, weight and size are different from the cultivated population. The tubercles are brick red. Lower lateral tubercles are prominent and green. The lateral line is very prominent and yellowish with a green shade. The white shining spots extend around the base of dorsal tubercles from second thoracic to eight abdominal segments. All the species are polyphagous,

**Table 2**: List of host plants of wild silk moths in Nagaland

| Silkworm species | Name of host plants | Vernacular names of host plants | Distribution of host plants |
|---|---|---|---|
| 1. (a) *Antheraea assamensis* (commercially reared) | *Persea gamblei* (= *P. bombycina*) | Som | Mokokchung, Wokha, Tuensang, Dimapur |
| (b) *Antheraea assamensis* (wild) | *Litsea monopetala* (= *L. polyantha*) | Soalu | |
| | *Litsea salicifolia* | Dighloti | |
| | *Litsea cubeba* (= *L. citrata*) | Mejankari | |
| 2. *Antheraea proylei* | *Quercus acutissima* | Oak trees | Kohima, Phek, Kiphire, Tuensang, Mokokchung |
| | *Quercus griffithii* | | |
| | *Quercus semeserrata* | | |
| | *Quercus incana* | | |
| 3. *Antheraea roylei* | *Terminalia myriocarpa* | Hollock | Throughout Nagaland |
| | *Betula alnoides* | Meriamtong | |
| 4. *Attacus atlas* | *Maesa indica* | | Mokokchung, Wokha, Phek, Zunheboto |
| 5. *Actias selene* | *Rhus javanica* | Tangmo | Throughout Nagaland |
| | *Alnus nepalensis* | Alder | |
| | *Betula alnoides* | Meriamtong | |
| | *Prunus cerasuides* | Cherry | |
| | *Evodia fraxinifolia* | Payam | |
| | *Persea gamblei* | Som | |
| 6. *Cricula trifenestrata* | *Persea gamblei* | Som | Mokokchung, Tuensang, Wokha, Dimapur |
| | *Litsea cubeba* | Mejankari | |
| | *Betula alnoides* | Meriamtong | |
| 7. *Samia ricini* | *Ricinus communis* | Castor | Throughout Nagaland |
| | *Heteropanax fragrans* | Kesseru | |
| | *Evodia fraxinifolia* | Payam | |
| | *Manihot esculanta* | Cassava / Tapioca | |
| 8. *Samia canningi* | *Ricinus communis* | Castor | Throughout Nagaland |
| | *Heteropanax fragrans* | Kesseru | |
| | *Evodia fraxinifolia* | Payam | |
| | *Manihot esculanta* | Cassava / Tapioca | |
| | *Duanbanga sonneritoides* | Khokon | |
| | *Anthocephalus cadamba* | Kadam | |
| | *Litsea salicifolia* | Dighloti | |
| | *Litsea cubeba* | Mejankari | |
| | *Psidium guajava* | Guava | |
| | *Zanthoxylum armatum* | Mejanga | |

feeding on more than one plant. Except for a few host plants, which are site specific, others are found throughout Nagaland (Table 2).

The eight wild silk moth species were reared on their most suitable host plants to analyse the morphological characteristics. They exhibit biodiversity in all aspects of their lives from egg to adult stages and in their food habits, consumption and morphological traits among themselves (Table 3 a,b). The species were seen distributed in different parts of the state. Except for *Antheraea roylei*, which produce double layered cocoon, all other silkworms produce cocoons with a single layer. *Cricula trifenestrata* is conspicuous in

**Table 3a**: Morphological characteristics of certain wild silk moths in Nagaland

| Characteristics | *A. assamensis* (W) | *A. assamensis* (C) | *Actias selene* | *Samia canningi* |
|---|---|---|---|---|
| **EGG** | | | | |
| Colour | Reddish brown to blackish brown | Reddish brown to blackish brown | Grey | Brownish to creamy white |
| Size (mm) | 2.0-2.5 x 1.8-2.0 | 2.5 x 2.2 | 2.5 x 2.3 | 1.6 x 1.2 |
| Weight (gm) | 0.008 | 0.005-0.007 | 0.004 | 0.001 |
| **LARVA Early** | | | | |
| Colour | Orange-yellow | Orange-yellow | Chocolate to orange brown | Yellowish black |
| Size (mm) | 8.6-12 x 1.0-2.0 | 9.8-10.2 x 1.0-2.0 | 7.2-7.8 x 1.4-1.6 | 7.1-7.3 x 1.2-1.5 |
| Weight (gm) | 0.03-0.06 | 0.02-0.07 | 0.03-0.05 | 0.01-0.05 |
| **Mature** | | | | |
| Colour | Light to dark green, brick red tubercles | Light to deep green | Dark green to light green | Yellowish |
| Size (mm) | 82-106 x 14-16 | 82.8-90.7 x 1.3-1.6 | 78.6-85.4 x 13.8-14 | 69-72.8 x 11.4-12.4 |
| Weight (gm) | 8.5-13.8 | 7.5-7.8 | 11.4-11.6 | 5.5-6.1 |
| **COCOON** | Single layered | Single layered | Single layered | Single layered |
| Colour | White to pinkish golden brown | Golden to light brown | Pale creamish | Grey, orange brown brick red |
| Size (mm) | 45.4-51.2 x 13.8-16.4 | 42.3-50.1 x 15.4-20.8 | 45.8-58.8 x 21.6-25 | 35.6-44.6 x 11.8-16.6 |
| Weight (gm) | 5.14-8.33 | 4.6-6.0 | 6.94-8.70 | 1.64-2.69 |
| Peduncle (mm) | 70-137 | 15-52 | – | 77-164 |
| Shell wt. (gm) | 0.55-0.75 | 0.54-0.71 | 0.29-0.55 | 0.22-0.40 |
| Shell ratio | 9.87-12.65% | 9.45-11.87% | 5.35-7.13% | 11.16-15.75% |
| Filament (m) | 304.76-364.6 | 365.5-409.2 | 135-242 | – |
| Denier (d) | 4.9-5.0 | 5.1-5.7 | 7.85-8.93 | – |
| **PUPA** | | | | |
| Size (mm) | 41-42 x 11.8-14.4 | 34.5-42.3 x 13.3-14.4 | 36-55.2 x 9.6-17.4 | 23.4-28.2 x 7.2-9.0 |
| Weight (gm) | 4.90-7.56 | 4.31-5.34 | 4.34-9.47 | 1.41-2.38 |
| **MOTH** | | | | |
| Wing expanse (cm) | | | | |
| Male | 14.6-14.7 | 10.6-13.5 | 12.3-14.1 | 11.5-12.6 |
| Female | 16.6-16.9 | 12.4-15.1 | 15.6-18.9 | 14.1-15.5 |
| Colour | | | | |
| Male | Chocolate to orange brown | Deep brown | Blue green to chocolate | Dark brown to pinkish white |
| Female | Orange to reddish brown | Light brown | Blue green to chocolate | Dark brown to pinkish white |
| Voltinism | Trivoltine | Multivoltine | Trivoltine | Bivoltine |

W: wild variety; C: commercially reared

**Table 3b**: Morphological characteristics of certain wild silk moths in Nagaland

| Characteristics | *Samia ricini* | *Antheraea roylei* | *Antheraea proylei* | *Cricula trifenestrata* |
|---|---|---|---|---|
| **EGG** | | | | |
| Colour | Ivory white | Greyish brown to bluish green | Blackish brown to bluish green | Ivory white |
| Size (mm) | 1.9 x 1.3 | 2.8 x 2.4 | 2.8 x 2.5 | 1.8 x 1.2 |
| Weight (gm) | 0.002 | 0.005-0.009 | 0.006-0.008 | 0.004 |
| **LARVA Early** | | | | |
| Colour | Yellowish black | Black | Black | Yellowish brown |
| Size (mm) | 5.8 x 1.8 | 9.4 x 1.7 | 9.6 x 0.18 | 6.2-6.6 x 1.2 |
| Weight (gm) | 0.02-0.05 | 0.027 | 0.034 | 0.029-0.033 |
| **Mature** | | | | |
| Colour | Creamy | Green with bluish tubercles | Green-purple to bluish tubercles | Dark brown to pinkish bands |
| Size (mm) | 64-70 x 10.2-10.6 | 96.6 x 15.8 | 86.4 x 13.8 | 56.4-60 x 7.0-8.6 |
| Weight (gm) | 8.2 | 12.5-23.1 | 13.10 | 2.52-2.56 |
| **COCOON** | Single layered | Doubled layered | Single layered | Perforated |
| Colour | Dark to reddish brown | Whitish | Reddish brown to light metallic | Golden yellow |
| Size (mm) | 43.8-46.8 x 16.4-19.4 | 45.4-54 x 24.4-27.4 | 41.6-5.10 x 18.2-27.4 | 30-41.6 x 7.2-14.4 |
| Weight (gm) | 4.12-4.28 | 6.6-11.5 | 4.92-7.62 | 0.958-2.01 |
| Peduncle (mm) | – | 93.2-170.4 | 46.0-63.4 | 62.2-93.6 |
| Shell wt. (gm) | 0.58-0.64 | 0.55-0.80 | 0.55-0.78 | 0.102-0.228 |
| Shell ratio | 13.5-14.9% | 6.96-8.30% | 10.18-12.35% | 8.0-13.33% |
| Filament (m) | – | 234-473 | 270-546 | – |
| Denier (d) | – | 4.7-5.7 | 4.9 | – |
| **PUPA** | | | | |
| Size (mm) | 28.2-29.0 x 10.4-11.6 | 38.2-45.2 x 18.2-28.6 | 36.6-40.8 x 14.8-21.6 | 22.2-27.6 x 4.8-11.2 |
| Weight (gm) | 3.54-3.64 | 4.51-11.18 | 4.33-6.84 | 0.84-1.78 |
| **MOTH** | | | | |
| Wing expanse (cm) | | | | |
| Male | 10.5-13.5 | 13.2-15.5 | 12.3-15.3 | 5.6-7.8 |
| Female | 11.5-14.1 | 15.2-17.5 | 13.5-17.2 | 7.5-8.1 |
| Colour | | | | |
| Male | Brown and black with pink border | Greenish-grey | Greyish brown | Orange brown |
| Female | Brown and black with pink border | Yellowish brown to dull brown | Greenish brown | Orange brown |
| Voltinism | Multivoltine | Bivoltine | Bivoltine | Bivoltine |

having perforated a cocoon. Shell ratio is minimum in *Actias selene* and maximum in *Samia ricini*, the domesticated eri silk cocoon. The length of a single cocoon filament was maximum in the cultivated *Antheraea assamensis* and minimum in *Actias selene*; however, denier is minimum in *Antheraea assamensis*.

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## 13. FIRST RECORD OF THE COLOUR SERGEANT *ATHYMA NEFTE* IN PHANSAD WILDLIFE SANCTUARY IN RAIGAD DISTRICT, MAHARASHTRA, INDIA

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The Colour Sergeant *Athyma nefte* (Cramer) is distributed in North-east Himalayas from Sikkim to Arunachal Pradesh, from Nepal and Bhutan; and from Bangladesh and Myanmar to Orissa and Andaman Islands (Evans 1932; Wynter-Blyth 1957; Kehimkar 2008).

In southern India, Mr. Rhodes-Morgan collected a single male specimen from the Wynaad district of Kerala (de Nicéville 1886). The Colour Sergeant (*Athyma nefte*) belongs to the Family Nymphalidae and is classified as rare to southern India by de Nicéville (1886).

We saw a Colour Sergeant on November 09, 2007, in Phansad Wildlife Sanctuary, which is about 45 km west to the Western Ghats crestline. It was basking on a small shrub in bright sunlight at around 0900 hours in "Chikhalgaan" area. Evans (1932), Wynter Blyth (1957) and Kehimkar (2008) stated that this butterfly prefers wet and hilly regions of evergreen forests of the Western Ghats. The occurrence of this butterfly in Phansad, the first record of this butterfly from Maharashtra, indicates that this could be the northernmost extension of *c.* 340 km from the known record – a male Colour Sergeant in Goa, in August 2008 (D. Raju, pers. comm.).

The information on the distribution of this butterfly is anecdotal, especially from southern India. Intensive field survey all over the northern Western Ghats is essential to evaluate the distributional range and present status.

ACKNOWLEDGEMENTS

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# 14. BIOLOGY OF THE PALM KING *AMATHUSIA PHIDIPPUS*, AN EXTREMELY RARE AND ENDANGERED BUTTERFLY OF PENINSULAR INDIA

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## Introduction

The Palm King *Amathusia phidippus* Linnaeus is an extremely rare and endangered species of butterfly that is strictly restricted to the southernmost tip of peninsular India, widely known as the Travancore in the State of Kerala (Wynter-Blyth 1957). Occurrence of several races of this species has been reported from Myanmar, Andamans, Java, Bali, Philippine Islands and Borneo (Abrera 1985). In India, Palm King has only been recorded from Travancore, near coconut groves. The species is reported to be locally common in areas where coconut groves are widespread and there appears to be no reason why they are rare at other areas of Kerala where there is substantially good availability of host plants along with comparable levels of temperature and humidity at similar altitudes (Wynter-Blyth 1957). Its rarity, patchy distribution and restricted habitat preferences makes it one of the few Oriental butterflies having a high conservation value (Conservation Value 33 out of 40; Kunte 2008). Recently, a small population of this butterfly was observed on ornamental palms in the Thenmala Ecotourism area in Kollam district, Kerala. The collected eggs in the field were reared on ornamental palms to study their biology. The information generated in this study is presented in this paper.

The collected eggs were reared on a potted ornamental palm *Dypsis lutescens* with sufficient foliage. The plant with the caterpillars was kept in a protected room with adequate aeration, sunlight and humidity to save them from predators and environmental hazards. The various stages were observed, photographed and length of different stages recorded.

Of the seven caterpillars that hatched out, two larvae were found to be dead and one was found missing. The remaining four caterpillars successfully matured, pupated and hatched to healthy adults which were later released in a garden containing several host plants, including the ornamental palm *Dypsis lutescens*.

## Life cycle of Palm King

**Eggs**: The freshly laid eggs are creamy white with a small black spot in the centre and a black circular ring. The eggs are laid in a row. At Thenmala, we observed two rows, the first having 15 eggs and the second 3 eggs (Fig. 1a). Prior to hatching, the colour of the egg changes to black. Eggs hatch in 6 to 7 days.

**Larvae**: The first instar larvae are cylindrical, measuring 0.6 to 0.8 mm in length. The head is disproportionately large, round, black and shiny. The thoracic and abdominal segments are pale yellowish bearing slender, white hairs (Fig. 1b). The last segment has two black spines that look like tails with no additional hairs on them. The first moulting takes place on the fourth day.

The second instar larvae are pale greenish yellow measuring 0.8 to 1.2 mm in length. The head is black and globular with tiny slender white hairs. The hairs on the upper side of the thoracic segments are stouter than the rest of the body hairs, and are directed towards the head. There are two pairs of diffused whitish lines that run from the dorsum of the first thoracic segment to the last abdominal segment. Three black spots are present on the upper side of the third and fourth abdominal segments; the fifth, sixth and seventh segments have two black spots each. The eighth abdominal segment has a characteristic wide-belly bottle shaped black mark with its neck directed towards the ninth segment, which has an additional black spot (Fig. 1c). The last abdominal segment bears two black spines, which have many small hairs on them. As the larvae mature, the third thoracic segment develops a bright orange fold of skin which gives the caterpillar a peculiar striped appearance. After about five days of heavy eating and growth they undergo the second moulting.

The third instar larvae are morphologically very similar to the previous instar, but are longer (3 to 4 cm) and stouter. They are darker and more greenish than yellowish and had a striped appearance due to the wider body lines (Fig. 1d). The black spots increase in number and size giving a mottled

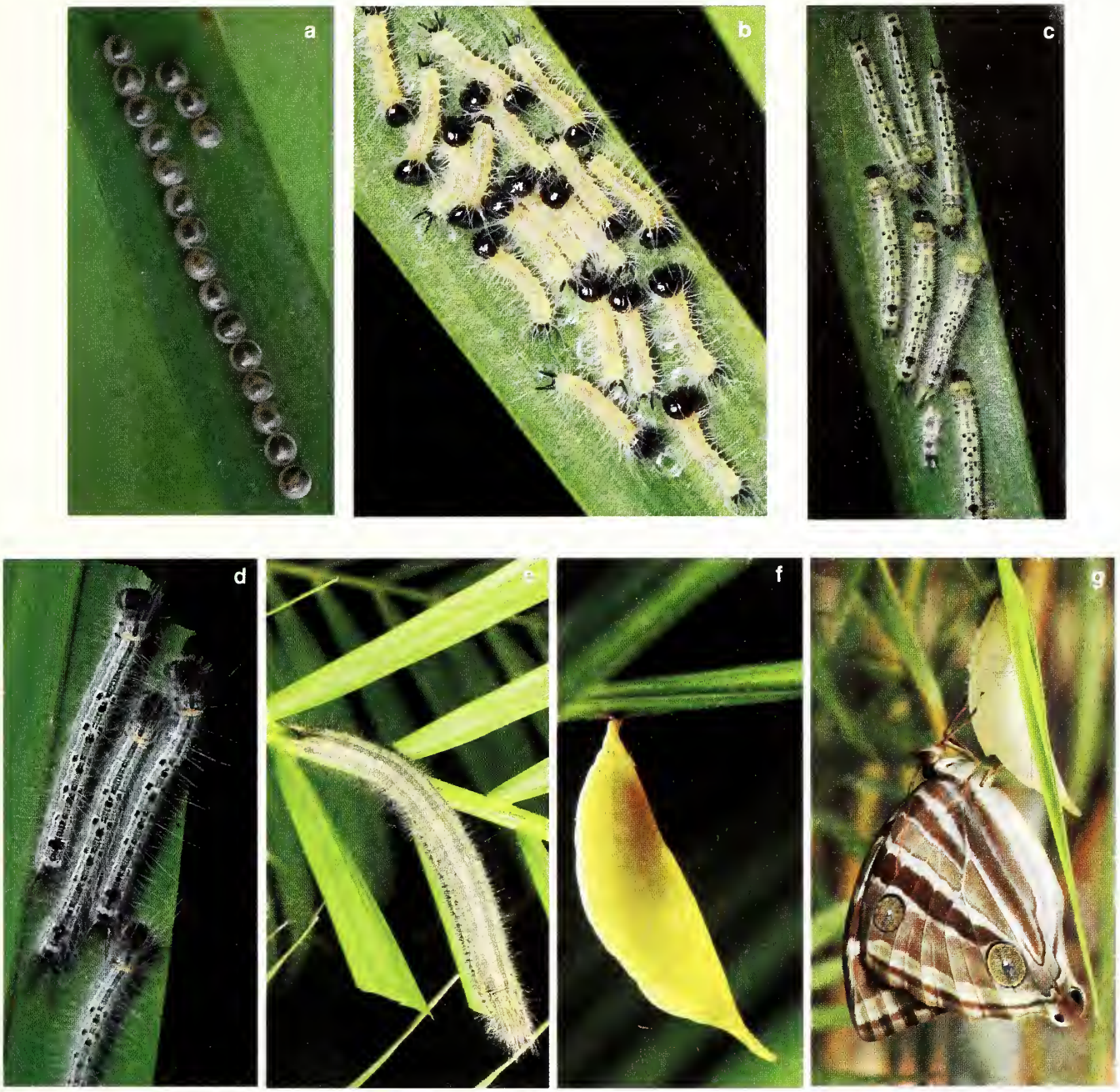


Fig. 1: *Amathusia phidippus*: a. Egg, b. First Instar, c. Second Instar, d. Third Instar, e. Fifth Instar, f. Pupa, g. Adult female

appearance. The hairs of the thoracic segments, which are pointed at the tip, grow stouter and longer almost hiding the greyish black head. The orange fold of skin over the third thoracic segment is also more prominent. The wide-belly bottle shaped black mark is more diffused and less prominent. The spines of the last segment grow paler. The larvae rested for moulting on the fifth day.

The fourth instar larvae are stouter and longer measuring 4.5 to 5.0 cm. They almost lose their colours and become nearly black and white. The stripes become greyish white or white. The orange strap on the third thoracic segment almost disappear with only the skin fold left with longer bright white hairs. The body appears more mottled with black. The bottle-shaped mark becomes nearly indistinct and diffuse with the background. The spines on the last segment are greyish white. The fourth moulting occurs on the sixth day.

During the fifth instar, the larvae become more brownish and measure 7.0 to 7.5 cm in length. They appear very stout and strong. The hair is white with a few scattered brown ones. The head has a new hand-like appendage with

four finger-like pointed branches (Fig. 1e). The thoracic hairs which project to the front nearly hide the head and appendages. The spines of the last segment are now of the same colour as the body. On the 12th and 13th day of the last instar, the larvae start to pupate.

Larvae of the Palm King are voracious feeders. Most of the time, they remain on the underside of the leaf, eating from the tip of the leaf working towards the base. The early instars prefer to remain in group and never stray away. But, as they mature, some moved away from the group, the behaviour being most marked in the last instar and peaked towards the days of pupation. The later instars prefer to remain on the upper side of the leaf as well.

With regard to coloration, the fifth instars show marked difference in their ground colour, some being more brownish and some more greyish. A link between the body colour and the future sex of the adult has to be established with more studies. A larger number of the caterpillars have to be observed to establish this link.

**Pupa**: The process of pupation takes about half a day. The greenish spindle-shaped pupa is well-camouflaged among the pointed leaves of the host plant (Fig. 1f). Initially, it is semi-transparent but later it becomes more opaque. The pupa has veins and lines similar to that of the leaves of the host plant, all veins ending at the pointed lower end of the pupa. The pupa becomes transparent on the eve of hatching, with the wings and head clearly visible. The hatching takes place on the 12th and 13th day of pupation.

**Eclosion**: All of the pupae hatched on two consecutive days between 0800 and 0900 hrs. The imago rested for about an hour and went on wings to rest in the shady bushes nearby.

**Imago**: ♂ ♀: Chocolate brown in colour having a wing span of 80-90 mm in specimens bred at Thenmala (Fig. 1g), although Wynter-Blyth (1957) states the wing span as 100-125 mm. Apex of forewing slightly conical; termen more or less straight; dorsum straight. Hind wing is with the dorsum expanded and flap-like, bare and pale brownish. Tornus produced into a slight conical lobe bearing two round black spots surrounded by a white ring dorsally and ventrally. Under side of both wings with a narrow marginal white band and a series of brown and white straight bands across. Two large eye spots at the apical and discal areas of the hind wing. Hind wing lobed at tornus. Velvety brown above. Upper forewing with diffuse yellowish band (which is prominent in female) just below apex and a narrow terminal yellowish band. Upper side of hindwing border-pale brown, bearing a dark marginal line.

**Female**: Abdomen with tufts on either side. Upperside of hind wing with fold and tuft and long erect hairs along base.

## ACKNOWLEDGEMENTS

We would like to specially thank Mr. Sandex, a young naturalist, who spotted the eggs of the Palm King at Thenmala, Kollam district of Kerala. Without his help, we could not have done this study at this time. We thank Ms. Sandhya Krishnan who patiently and painstakingly observed and took all care to avoid predation of the caterpillars during the study. We thank Dr. Biju C.R., Mr. Sasi Menon and other members of The Butterfly Art Foundation, India, for their assistance at various stages of the study. We also thank Mr. Isaac Kehimkar, Krushnamegh Kunte, C. Susanth and other members of the Butterfly India Group for their encouragement.

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# 15. ON THE COLLECTION OF THREE INTERESTING SPECIES OF *LEJEUNEA* LIB. FROM ABBOTT MOUNT, WESTERN HIMALAYA , INDIA

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## Introduction

The genus *Lejeunea* Lib. (Hepaticae; Division Bryophyta) is represented by 21 species in India, of which, till recently, only seven species were known from the Western Himalaya, namely *L. bidentula* Herz., *L. cocoes* Mitt., *L. cavifolia* (Ehrn.) Lindenb., *L. nepalensis* Steph., *L. tuberculosa* Steph., *L. flava* (Swartz.) Nees and *L. wightii* Lindenb. (Mizutani 1964, 1971; Srivastava and Parihar 1986;

Bapna and Kachroo 2000; Singh 2001; Singh and Singh 2004). Among these, *L. flava*, *L. nepalensis* and *L. cocoes* are little known and needed further verification based on fresh collection from the region.

During the process of taxonomic revision of the genus, the authors critically examined specimens of *Lejeunea* collected from Abbott Mount, near Lohaghat in Champawat district, Uttarakhand (28° 22' N; 80° 06' E; altitudes 1,950 to 2,010 m). Based on this study a key for the identification of the above mentioned taxa is being given in this communication along with their salient morphological features, specimens examined and the present distribution.

1 Lower leaves distant, never two times wider than stem width ..... 2

— Lower leaves imbricate, nearly four times wider than stem width ..... *L. flava*

2 Lower leaves obliquely spreading never lunate; stem flexuose (zig-zag), sparsely branched ..... *L. nepalensis*

— Lower leaves ovate-lunate; stem straight, frequently branched ..... *L. cocoes*

1. ***Lejeunea flava* (Swartz.) Nees** (Fig. 1: A-I)

*Lejeunea flava* (Swartz.) Nees *Naturg. Europ. Leberum. 3*: 277 (1838); Mizutani, *Journ. Hattori Bot. Lab. 24*: 207 (1961).

The species can be identified on the basis of (i) imbricate leaves with slightly convex and oblong ovate leaf-lobes, (ii) closely imbricate lower leaves, nearly four times broader than the stem, bilobed for 1/3 the length, and (iii) pyriform sporangial leaves, which is slightly and obtusely 5-angled above. There is a slight variation in the degree of overlap in lower leaves among the plants collected from Himachal Pradesh and Uttarakhand, and interestingly the descriptions based on specimens collected from Nilgiris (Srivastava and Verma 2004) resemble closely with that of Uttarakhand.

The species prefers smooth bark of the trees of *Pieris ovalifolia* and is found in association with the mosses, such as *Brothera himalayana* Broth. and *Dicranum* sp.

**Type locality**: Jamaica

**Distribution**: West Indies, Bermuda, Mexico, Guatemala, Honduras, Panama, Nepal, Japan, Formosa, Sumatra, Europe, Madeira, Tenerifa, Australia, Africa, New Zealand N. America and S. America. INDIA: North-eastern Hill States (Manipur, Meghalaya), West Bengal, southern India (Dodabetta, Nilghiri Hills, Ootacamund, Palni Hills, Kerala), and Western Himalaya (Himachal Pradesh). This is the first report of this species from the state of Uttarakhand.

**Specimen Examined**: Abbott Mount in Champawat district in Uttarakhand: H-79/10, 2,010 m above msl, January 1979, Herbarium, Allahabad University.

2. ***Lejeunea nepalensis* Steph.** (Fig. 1: J-Q)

*Lejeunea nepalensis* Steph. *Sp. Hepat. 5*: 780 (1915); Mizutani, *Journ. Hattori Botanical Lab.34*: 455 (1971).

The species can be identified by its (i) flexuose stem, (ii) seven rows of cortical cells, which are much larger than the medullary cells, (iii) strongly arched base of the dorsal margin of the leaf-lobe, (iv) small leaf-lobule, about 1/4 the length of the leaf-lobe, (v) obliquely spreading leaves, and (vi) it being dioecious.

The plants of the present population from Kumaun are sturdier and have greater number of microsporangia per plant.

The species is endemic to the Indian subcontinent. It grows on the trunks of the oak tree, *Quercus leucotrichophora* along with some pleurocarpous mosses.

**Type locality**: Nepal.

**Distribution**: INDIA: Eastern Himalaya (Darjeeling, Assam, Sikkim); Western Himalaya (Mussoorie). This is the first report of this species from Kumaon region.

**Specimen Examined**: Abbott Mount in Champawat district, Uttarakhand: H-79/56, 2,000 m above msl, June 1979, Herbarium, Allahabad University

3. ***Lejeunea cocoes* Mitt.** (Fig. 2: A-N)

*Lejeunea cocoes* Mitt. *Journ. Proc. Linn. Soc.*, London, *5*: 114 (1861); Mizutani, *Journ. Hattori Bot. Lab. 26*: 176 (1963)

The diagnostic characters of the present species include (i) whitish green, irregularly pinnately branched plants, (ii) distant, sub-erect spreading leaves, (iii) distantly placed lunate lower leaves, (iv) dioecious sexuality, (v) female bracteole being connate with bracts at both sides, and (vi) obovate, inflated sporangial leaves, weakly 5-keeled.

This species grows on the trunk of the oak tree, *Quercus leucotrichophora*, under very shady and humid conditions. The species was recorded from the bark of the coconut tree, *Cocos nucifera*, in the 'type' locality.

**Type locality**: Balagom, Ceylon

**Distribution**: Sarawak, Java and China. This is the first authentic report of the species from India.

**Specimen Examined**: Abbott Mount in Champawat district, Uttarakhand: 301/78, 2,010 m above msl, January 1978, Herbarium, Allahabad University.

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We are thankful to Dr. Virendra Nath, National Botanical Research Institute, Lucknow, for providing relevant literature.

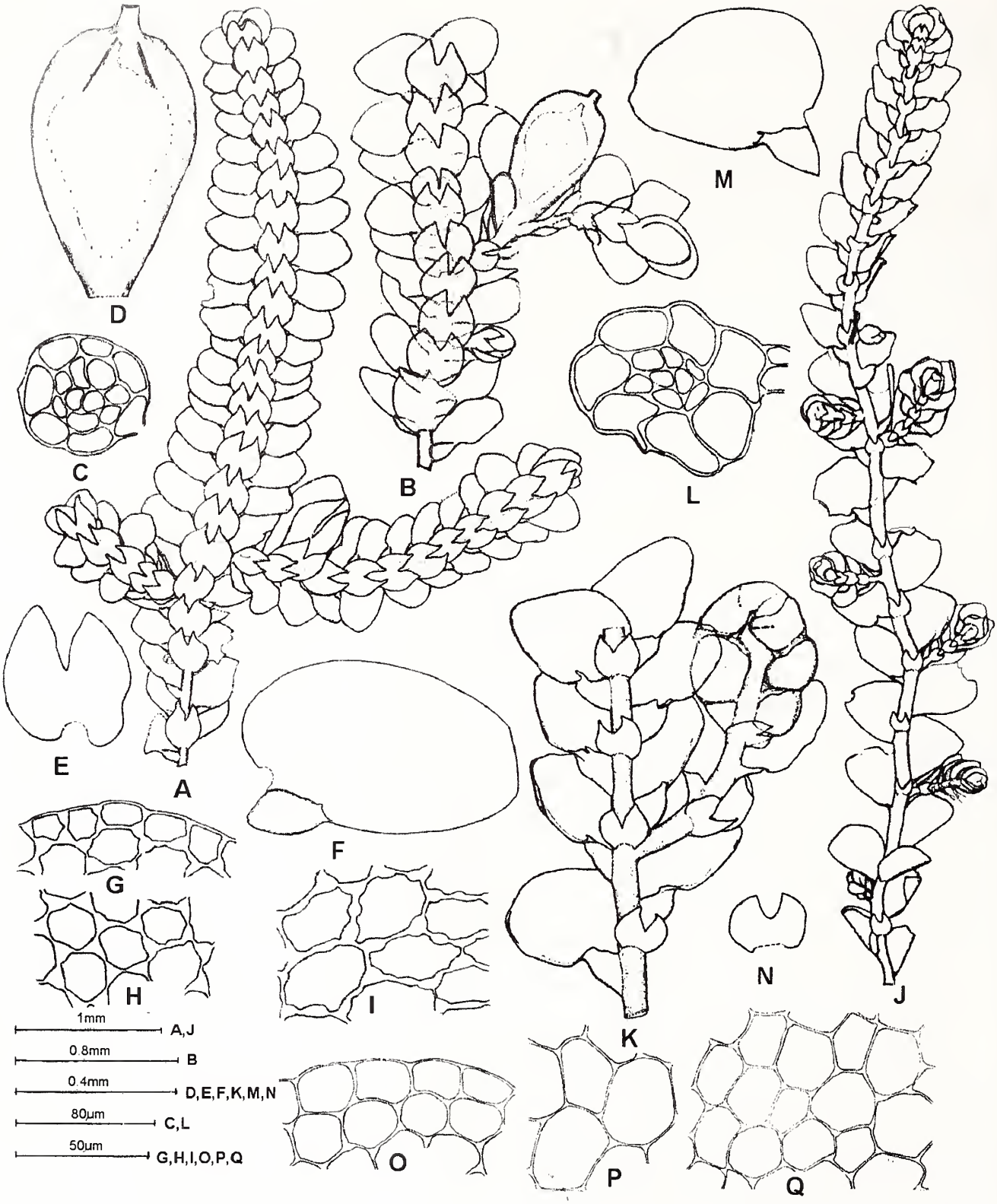


Fig. 1: *Lejeunea flava* (Swartz.) Nees (A-I): A. Part of a plant, ventral view; B. Part of the plant with perianth, ventral view; C. Stem, t.s.; D. Perianth, magnified; E. Underleaf; F. Leaf; G. Marginal cells of the leaf-lobe; H. Median cells of the leaf-lobe; I. Basal cells of the leaf-lobe

*Lejeunea nepalensis* Steph. (J-Q): J. Part of a plant, ventral view; K. Part of the plant with male inflorescence, ventral view; L. Stem, t.s; M. Leaf; N. Underleaf; O. Marginal cells of the leaf-lobe; P. Basal cells of the leaf-lobe; Q. Median cells of the leaf-lobe

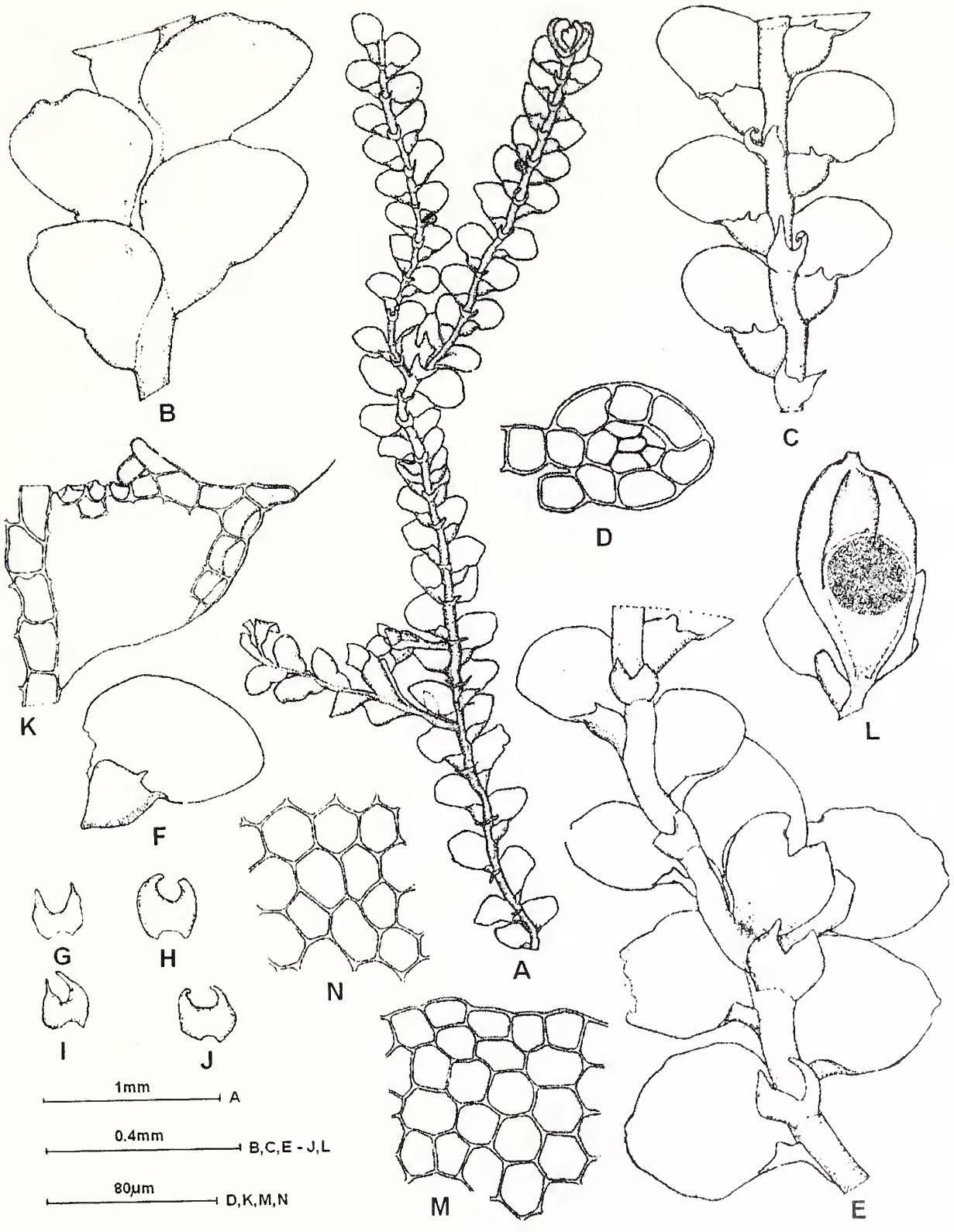


Fig. 2: *Lejeunea cocoes* Mitt. (A-N):
A. Part of a plant, ventral view; B. Part of the plant, dorsal view; C.Part of a plant, ventral view;
D. Stem, t.s.; E. Part of the plant with a sub floral innovation (though perianth is absent, bracts and bracteoles are present);
F. Leaf; G, H, I. & J. Underleaves; K. Leaf-lobule magnified; L. Perianth; M. Marginal cells of the leaf-lobe;
N. Median cells of the leaf-lobe

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# 16. *CALATHODES POLYCARPA* OHWI (RANUNCULACEAE) — A NEW RECORD FOR INDIA


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The genus *Calathodes* Hook. *f.* & Thomson (Family: Ranunculaceae) was established by Hook. *f.* & Thomson (1855) with the description of only one species *Calathodes palmata* Hook. *f.* & Thomson based on the collection from Sikkim, 3,000 m above msl, J.D. Hooker, *s.n.*

Later, three more species were added, namely *C. oxycarpa* Sprague (in Bull. *Misc. Inform. Kew* 1919: 403.1919); *C. polycarpa* Ohwi (in *Acta Phytotax. Geobot. 2*: 153.1933) and *C. unciformis* Wang (in *Bull. Bot. Res., Harbin 16*: 165.1996), all considered to be endemic to China (Liangqian and Tamura 2001). However, later *C. polycarpa* Ohwi was recorded from Formosa, Japan, by Ohwi (*l.c.*) based on the specimen *Ohwi* 4211 and also noted to be present in Taiwan.

During the floristic study of Kanchenjunga Biosphere Reserve, Sikkim, as well as Sikkim Himalaya, we collected one specimen from Zemu valley, between Log Bridge and Jakthang (Maity and Maiti 21373) with the following distinguishing features: greenish-white flowers, numerous (*c.* 30) carpels with gibbous-deltoid base and shorter styles, different from that of the commonly known Sikkimese species *C. palmata* Hook. *f.* & Thomson.

A critical study revealed its identity as *Calathodes polycarpa* Ohwi, which is a new record to India. Moreover, its disjunct distribution is now known in Sikkim (India), Formosa, China, Japan and Taiwan.

The collected specimen of *Calathodes* was identified as *C. polycarpa* Ohwi by matching with the protologue and Liangqian and Tamura (2001), and solely based on the field observation and examination of the collected plants.

Detailed description along with illustration is provided here. It is also compared with *Calathodes palmata* (Table 1) and a key of known four species of *Calathodes* is given to facilitate its identity.

**Key to the species of *Calathodes***

1. Flowers white or greenish white ..... 2
— Flowers yellow ..... 3
2. Lamina 2-3 x 3.2-5 cm; carpels 7-15 ..... *C. oxycarpa*
— Lamina 4-6 x 6-9 cm; carpels 30-60 ..... *C. polycarpa*
3. Carpels less than 20, without projection ..... *C. palmata*
— Carpels more then 30, with projection ..... *C. unciformis*

***Calathodes polycarpa*** Ohwi in *Acta Phytotax. Geobot. 2*: 153. 1933; Liangqian & Tamura, Fl. China 6: 137. 2001 (Fig. 1).

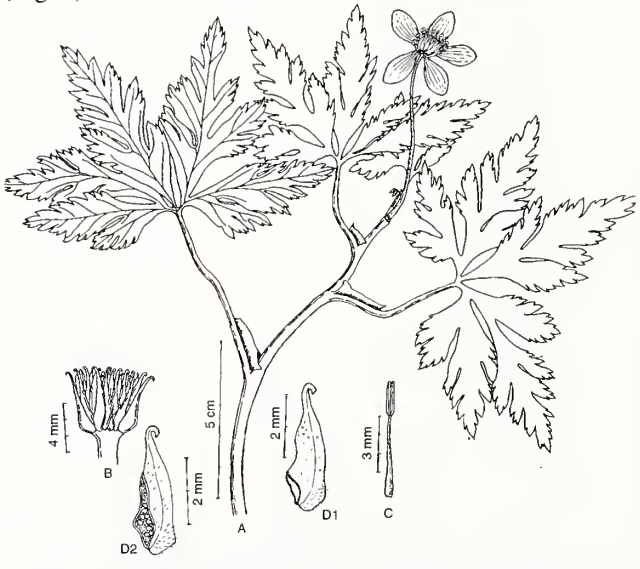


Fig. 1: *Calathodes polycarpa*: A. Habit; B. Etario of follicles (immature); C. Stamen; D1. Carpel; D2. Carpel splitted in the lower part showing ovules (from Maity & Maiti 21373)

**Table 1**: Comparison of *C. palmata* and *C. polycarpa*

| Sl. No. | Important features | *C. palmata* | *C. polycarpa* |
|---|---|---|---|
| 1. | Leaf | Numerous | 5-7 |
| 2. | Flower colour | Yellow | White or greenish-white |
| 3. | Carpel | 10-15, oblong, base gibbous | 30-60, falcate-oblong, laterally compressed, base deltoid-gibbous |
| 4. | Follicle | Obliquely obovate, *c.* 9.0x4.5 mm | Dorsally keeled, suprabasal deltoid gibbous |
| 5. | Projection on carpel base | Absent | Present |

Terrestrial, erect herb, up to 55 cm tall; stems with few branches or simple, glabrous. Leaves 5-7, both rosette and cauline, palmately tripartite; lamina 4-6 x 6-9 cm, mid-lobe rhombic, 3-fid; laterals obliquely flabellate, unequally 2-parted; apex acute, margin incised-serrate, glabrous on both the surfaces; petioles 7-14 cm long, auriculate at base; auricles *c.* 1.5 cm long. Flower solitary, terminal, 1.8-3.0 cm diam., borne on *c.* 1.5 cm long pedicel; sepals petaloid, obovate-elliptic, 0.9-1.6 x 0.5-0.9 cm, white to greenish-white, glabrous; petals absent; stamens 15-20; filaments filiform, 3-7 mm long; anthers linear-oblongoid, 2.0-2.5 mm long, latrorse; carpels 30-60, falcate-oblong, 4-5 x 1 mm, laterally compressed; base deltoid-gibbous, sparsely papilose; style short, *c.* 1 mm long, recurved, Follicles 30-60, each 7-10 mm long with 1.5-2.0 mm long persistent style; projection distinct on dorsal surface.

**Specimen Examined**: North Sikkim, Zemu Valley, between Log Bridge and Jakthang, 3,000 m, 13.vi.1999, Maity & Maiti 21373-BSHC.

**Flowering & Fruiting**: June-August.

**Distribution**: INDIA: Sikkim; China, Taiwan, Japan, Formosa.

Grows on the forest floor, open grassy slopes in temperate forest between 1,800-3,000 m.

**Note**: In our specimen the number of carpels is about 30 and the deltoid-gobbous base is sparsely papilose.

**ACKNOWLEDGEMENT**

We are thankful to the Additional Director, Central National Herbarium (CAL), Howrah, for giving permission to consult the herbarium and library.

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## 17. *TRICHOSANTHES LOBATA* ROXB. (CUCURBITACEAE) — A NEW RECORD FOR GARHWAL HIMALAYA, INDIA

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The genus *Trichosanthes* (Cucurbitaceae) is represented by 22 species in India, and is distributed mainly in the tropics and sub-tropics (Chakravorty 1982). *Trichosanthes lobata* Roxb., closely allied to *T. cucumerina* L., is reported from Andhra Pradesh, Tamil Nadu, Uttar Pradesh and West Bengal. However, so far, there is no record of its occurrence from Uttarakhand (Uniyal *et al.* 2007). Floristic records from north-west Himalaya (Hooker 1872-1897; Duthie 1903-1929, 1906; Babu 1977; Raizada and Saxena 1978; Naithani 1984-1985; Gaur 1999) have no mention of this species from this part of the country.

During plant collections in the Alaknanda valley, the authors collected the species from open sloppy fields near the road side in the third week of August, 2008. The voucher specimen is deposited in the Herbarium, Department of Botany, H.N.B. Garhwal University, Srinagar, Garhwal (GUH).

The diagnostic characters, locality, field number and notes are given below:

***Trichosanthes lobata*** Roxb. *Fl. Ind. 3*: 703.1832: Kurz in *J. As. Soc. Beng. 46(2)*: 98. 1877; Clarke in Hook. f. *Fl. Brit. Ind. 2*: 610. 1879; Kundu in *J. Bombay Nat. Hist. Soc. 43*: 373. 1943.

**Diagnostic Characters**: Extensive climber, stems slender, sulcate. Leaves entire, 5- lobed, denticulate; petioles up to 8-10 cm long, puberulous; lamina 16-18 x 14-16 cm, membranous, suborbicular, base deeply cordate, slightly

puberulous on both surfaces. Tendrils trifid, divided about the middle.

**Male flowers**: In racemes, minutely bracteate, peduncles 18 to 20 cm long, slender, puberulous, 6-10 flowered; lower flowers arranged distantly, upper condensed. Pedicel 2.0 2.5 cm long, slender, calyx-tube 2.0-2.5 cm long, corolla fimbriate, without projections 1.0 x 0.3 cm. Stamens 3, inserted in the calyx tube, adnate, synandrous; anther lobes 0.3 cm x 0.1cm; filaments free, 0.1 cm in length. Pollen grains 3-zonicolpate (pollen grains with compound apperture, 3 porate colpi), sub-prolate (58.6 x 68.0 µ); exine 3.5 µ thick, reticulate.

**Female flowers**: Solitary, axillary, minutely bracteate; pedicel 1 cm in length; flower length 4.0-4.5 cm; calyx-tube 3.0-3.5 cm, corolla tube 1.4 cm; ovary 1.5-1.8 cm in length, covered with minute hairs; style long 1.5 cm; stigma trifid, 0.3 cm long. Fruits 18-22 x 12.0-14.5 cm; pedicel 1 cm; fruit surface glabrous; linear-oblong, streaked with white-green colours; green streaks 1.5 cm broad, white streaks 0.5 cm at base towards stalk. Seeds packed in bright red orange pulp, ellipsoid, 12-15 x 6-8 mm and 2.0-2.5 mm thick, flat, surface rugulose, margin denticulate, tubercled, truncate at the apex, much compressed at base.

**Flowering and Fruiting**: July-September.

**Ecology**: Occasional, along the wet edges of sloppy fields. Frequently associated with *Trichosanthes cucumerina*, *Coccinia grandis*, *Ampelocissus latifolia*, *Cassia tora*, *Murrya koenigii*, *Zizyphus mauritiana*, *Lantana camara*, *Euphorbia hirta* and *Physalis divaricata*.

**Specimen Examined**: Srinagar, GUH 2910

**ACKNOWLEDGEMENTS**

We thank Professor R.D. Gaur, Professor Emeritus, Department of Botany, H.N.B. Garhwal University for encouragement and herbarium facilities and Dr. Harish Singh, Scientist, Botanical Survey of India, Howrah, for providing literature.

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## 18. REDISCOVERY OF *HUGONIA MYSTAX* LINN. (LINACEAE) FROM MAHARASHTRA, INDIA

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***Hugonia myst*** Linn. Sp. Pl. 675 1753; Dalz. & Gibs. *Bombay Fl. 17*, 1861; Masters in Hook.f. *Fl. Brit. Ind. 1*:413, 1875; Cook, *Fl. Pres. Born. 1*:156, 1901; Talbot, *Trees Bombay 28*, 1902; Wight., I11. 02, 1840.

"Modira-Canni" Rheede, *Hort. Mal. 2*: 29-30, t. 19, 1679.

A rambling scandent shrub; branches yellow-tomentose, with short horizontal branchlets, leafless below and provided near the ends with a pair of circinate hooks. Leaves 4-6 by 2.5-4 cm, elliptic-obovate, obtuse or subacute, entire, reticulately veined, the veins conspicuous on both the surfaces, glabrous, base tapering; petioles 2 mm long, hairy; stipules lanceolate-subulate. Flowers at the extremities of the short branchlets 2.5-3 cm across, terminal and in the upper axile; pedicels short 1-flowered, clothed with soft yellow hairs. Sepals 7 mm long, ovate-lanceolate, acute, fulvous-pubescent. Petals many times longer than the sepals, thin, ovate-oblong, acute or truncate. Styles longer than the stamens; stigmas capitate. Drupes about 9 mm in diameter, globose, surrounded by the persistent sepals; bright red after maturity; pulp scanty; stone bony, grooved, 10-celled, with usually 2 or 3 seeds.

A rare plant found near the junction of river goes to sea on sandy areas among the other bushes. Few plants were seen at single spot.

**Fl. & Fr.**: August (Seen the plant in flowering and fruiting in December)

**Distribution**: Mochemad-Vengurla.

**Specimen Examined**: BGG - 2974 (BLAT)

This is the first report of this species after a gap of 145 years. It was reported by Dalzell & Gibson in Bombay Flora in 1861 based on collection of the species between Vengurla and Malvan. However, no specific locality has been given by Dalzell. Dalzell reported the flowering period of the plant as August, in rainy season, but I have seen the plant flowering and fruiting during December, in winter season. I have collected the specimens and taken the photographs of the same (Eds: photographic evidence provided).

In the FLORA OF SINDHUDURG DISTRICT (55,1988), Mr. B.G. Kulkarni reported this species, on authority of Dalzell. In FLORA OF MAHARASHTRA Vol. I: 175, 1996), M.R. Almeida has reported this plant on the authority of Dalzell, as well as in the FLORA OF MAHARASHTRA (Vol.1: 411, 2000) published by BSI. No other collector has been able to locate this species in Konkan. I have located this species while doing the plant survey of Vengurla taluka for my Ph.D. Degree.

## ACKNOWLEDGEMENTS

I sincerely thank my guide Dr. S.M. Almeida for help in determination of the species, Dr. M.R. Almeida for the assistance provided in the confirmation of the species and Dr. U.C. Bapat, the Director, Blatter Herbarium, St. Xavier's College, Mumbai for facilities rendered during my work.

# 19. A NEW RECORD OF *MONOTROPA HYPOPITYS* L., A MYCO-HETEROTROPHIC PLANT FROM INDIA

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A myco-heterotrophic plant *Monotropa hypopitys* L. is reported for the first time from India. The illustration, phenology, range of occurrence and conservation threat of the species have been presented in this paper.

About 400 species of vascular plants under 87 genera are achlorophyllous and heterotrophic, but not directly parasitic. These plants are unable to assimilate carbon by themselves and are mostly dependent on fungal association for nourishment. Hence, these saprophytic plants are called as myco-heterotrophic plants. Most myco-heterotrophic plants are restricted to the tropics and the diversity in terms of number of species and families is maximum in the Palaeotropical region (Leake 1994). The members belonging to the genus *Monotropa* are achlorophyllous, myco-heterotrophic plants. The subfamily Monotropoideae of Ericaceae consists of 10 genera and 12 species (Wallace 1975). *Monotropa* has a wide distribution throughout Europe, North America and Asia, with a circumboreal distribution extending northward almost up to the Arctic Circle (Wallace 1975). It is also found in far south, such as Mexico, Panama and Colombia (Maas 1986). However, in India, *Monotropa* is restricted to temperate Himalayas in Garhwal and Kumaon (Strachey 1974) and Khasi Hills (Hooker 1882; Haridasan and Rao 1985). Of the two species of *Monotropa*, namely *M. hypopitys* and *M. uniflora*, only *M. uniflora* has so far been recorded from these areas. While reporting *M. hypopitys* from China, Wallace (1975) included India as one of the countries where the species can be found. However, there was no mention of specific locality. Other than this, there is no published report on occurrence of *M. hypopitys* in India till date.

While establishing the identity of the species, the authors came across two specimens of the same species, one from Naga hills with collection No. 17636 (ASSAM) deposited by N.L. Bor in September, 1936, and another from Salari forest in East Kameng district of Arunachal Pradesh with collection No. 39961 (ASSAM) deposited by J. Joseph in September, 1964. However, the species was never collected from Meghalaya and was never published describing its occurrence in India.

*Monotrapa hypopitys* was discovered during the floristic exploration in two sacred forests of Meghalaya.

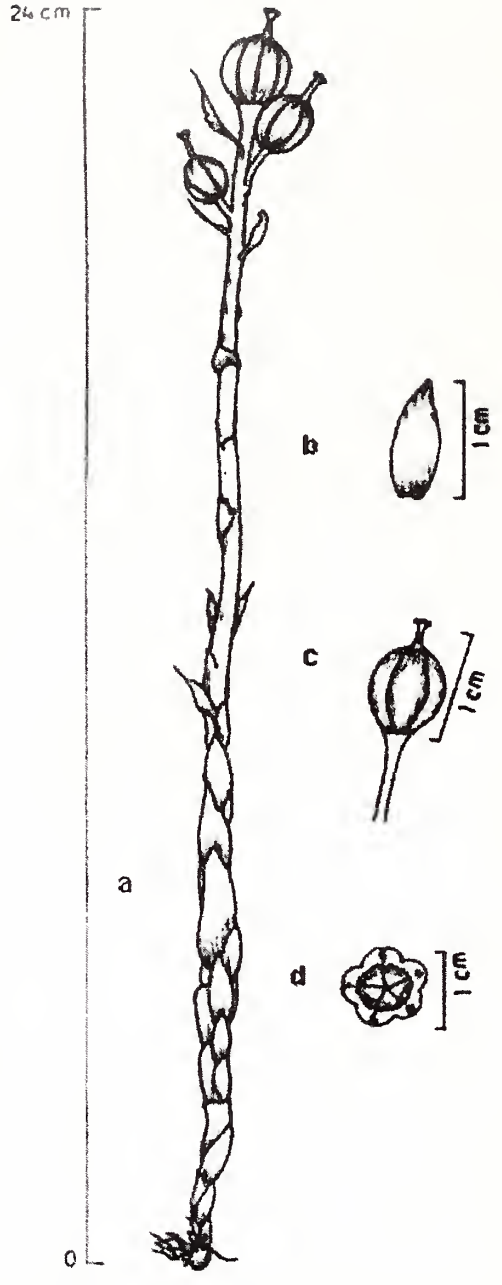


Fig. 1: *Monotropa hypopitys*: a. habit; b. bract; c. mature ovary and d. T.S. of ovary (Scale bar: a = 240 mm & b-d = 10 mm)

The identity of the species was established after comparing it with the two herbarium sheets deposited by Bor (1936) and Joseph (1964) mentioned above and consulting the FLORA OF CHINA (Zhengyi *et al.* 2005). The voucher specimen was deposited in Botanical Survey of India, Eastern Circle Herbarium (Assam), Shillong. The species is confined to two sacred forests, namely Mawphlang (25° 36. 810' N; 91° 54.113' E; 1,427 m above msl), and Upper Shillong (25°32.223' N; 91°51.231' E; 1,899 m above msl).

***Monotropa hypopitys*** L., Sp. Pl. 1: 387. 1753.

Plant annual, pale yellow-brown, fleshy, brown-black when dry. Inflorescence racemose, rarely reduced to a solitary flower, 5-35 cm long from root connection, 1-10 mm diameter, below the lowermost flower glabrous, emerging from soil in nodding position; bracts on axis below soil level, shorter and thicker and more densely crowded than upper bracts, elliptic to ovate, 8-15 x 3-15 mm, margins erose, irregularly toothed; pedicels slender, 2.5-15 mm long, up to 36 mm in fruit, 1-2 mm in diam., finely pubescent to nearly glabrous, glandular; bracteoles sometimes present, 9-14 x 4-10 mm. Flowers cylindric, often constricted distally; calyx distinct from corolla, sepals 4-5 or occassionally, 7-12 x 1-5 mm, usually pubescent within; corolla of 4-5 petals divergent at apices, 8-17 x 4-8 mm, oblong to oblanceolate, narrowly saccate at constricted base, rounded to acute at apices, usually reflexed at tip; stamens 8-10 in two series of alternating lengths, 5-14 mm long; anthers hippocrepiform, 0.8-1.5 mm long, dehiscing by a single terminal slit over the connate sacs; ovary 6-12 x 5-9 mm, usually pubescent, locules 4-5, stigma umbilicate, funnel form, 1.5-3.0 mm in diam., often subtended by a ring of stiff hairs; style uniformly slender, joining abruptly with ovary, 2-10 x 1-2 mm. Capsule erect, broadly ellipsoid, 5-10 x 5-9 mm (Fig. 1 and Table 1).

**Specimen Examined**: Naga hills, Nagaland, Bor 17636 (Acc. No. 6405-Assam), Salari, West Kameng district, Arunachal Pradesh, Joseph 39961 (Acc. No. 39797 Assam).

**Fl. & Fr.**: Fl. July-September and Fr. September-October.

**Table 1**: Distinguishing features of *M. hypopitys* L. and *M. uniflora* L.

| *M. hypopitys* | *M. uniflora* |
|---|---|
| Herbs pale yellow-brown | Herbs white when fresh, black when dry |
| 5-45 cm high | 5-30 cm high |
| Inflorescence racemose, rarely scapose | Inflorescence erect scapose |
| Petals and sepals distinct in texture and appearance, narrowly saccate at base | Petals and sepals similar in texture and appearance, broadly saccate at base |
| Nectar lobes short, stout | Nectar lobes elongate, cylinder, |
| Capsular walls thin, segments often deciduous at maturity | Capsular walls stout, segment persistent |
| Fruits many | Single fruit |
| Ovary 6-12 x 5-9 mm | Ovary 2-10 x 1-2 mm |

**Ecology**: The species grows on leaf litter as well as on the roots of *Quercus* spp. and the members of Family Lauraceae such as *Cinnamomun glanduliferum* (Wall) Meissn and *Persea odoratissima* (Nees) Kosterm. The fungal species that had mycorrhizal association with *M. hypopitys* were *Russula lepida* Fr., *Boletus luteus* L., *B. edulis* Bull. and *Tricholoma saponaceum* (Fr.) P. Kumm. The other fungal species present in the litter were *Scleroderma aurantium* (L.) Pers, *Amanita phalloides* (Vaill ex. Fr.) Link and *Hygrophorus limacinus* Kalchbr.

**Distribution**: China, Bhutan, Myanmar, Thailand, Russia, Pakistan, Europe, North America, Mexico and India.

**Threat status**: Following IUCN classification scheme Version 3.1 (2001), the species is assigned to the category 'Critically endangered'.

Being an achlorophyllous plant, *Monotropa hypopitys* depends on its association with mycorrhizal fungi for nutrition, which in turn are usually associated with the roots of selected tree species. The survival and reproduction of *M. hypopitys* seems to be extremely sensitive to forest microenvironment that encourages the mycorrhizal association between the angiosperm tree roots and fungi. Thus, the protection of the habitat holds key to the species conservation.

## ACKNOWLEDGEMENTS

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# 20. DOES *ACHYRANTHES BIDENDATA* BLUME (AMARANTHACEAE) OCCUR IN ANDAMAN & NICOBAR ISLANDS?

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The species *Achyranthes bidendata* Blume is widely distributed in the tropical countries mainly in Africa and Asia. In India, the species has been reported throughout the country from sea level to 1,000 m altitude. Vasudeva Rao (1986) reported this species from Nicobar Islands based on the earlier collections deposited in the Botanical Survey of India regional herbarium, Port Blair (PBL). Later, Sinha (1999) included it in his work based on the above report and collections. A critical examination of earlier collections with relevant literature reveals that all the specimens hitherto identified as *Achyranthes bidendata* Blume in PBL belong to *Cyathula prostrata* (L.) Blume. The genus *Cyathula* is closely allied to the genus *Achyranthes* L., but differs from it by having rhombate leaves and fascicled hooks around the glomerules of flowers. Thus, *Achyranthes bidendata* Blume may not occur on Andaman & Nicobar Islands. The present paper gives nomenclature and concise description of *Cyathula prostrata* together along with its distribution in the world and habitat.

***Cyathula prostrata*** (L.) Blume, Bijdr. 549. 1825; Hook. f., *Fl. Brit. India 4*: 723. 1885; Ridl., *Fl. Malay Penins. 3*: 7. 1924; Backer in Steenis, *Fl. Males. Ser. 1, Spermat. 4*: 82, t. 4. 1949; Larsen in *Fl. Thailand 5(4)*: 393, t. 86 (7-13). 1992. *Achyranthes prostrata* L. Sp. Pl. ed. 2, 296. 1762. *A. bidendata sensu* Vasudeva Rao in *J. Econ. Taxon. Bot. 8*: 140. 1986; Sinha, *Fl. Great Nicobar Isl.* 351. 1999. (*non.* Blume, 1826).

Erect or prostrate herb, up to 80 cm high; stem reddish-

brown, obtusely quadrangular, densely white hairy. Leaves simple, opposite, membranous, rhombate, 2-7 x 1-3 cm, acute at apex and base, margin entire, ciliate, patently hairy on both surfaces, reddish-brown above, greenish-brown beneath; petioles 5-7 mm long, channeled above, hairy. Inflorescence terminal, racemose, up to 26 cm long, densely pubescent; peduncles up to 8.5 cm long. Flowers in glomerules, sterile flowers often found in the lower parts and modified into hooked fascicles. Tepals lanceolate, *c.* 3 mm long, densely villous and pubescent within. Stamens 5, filaments at the base with a short connate cup; free parts alternating with dentate, pseudo-staminodes; anthers 2-celled. Ovary obovoid, *c.* 1 mm long; style very short. Seeds up to 1.2 mm long, shining brown.

**Fl. & Fr.**: March-August.

**Distribution**: INDIA: Throughout; Africa to China, throughout south-east Asia and Australia.

**Habitat**: Not common along the edges of evergreen and semi-evergreen forests.

**Specimens Examined**: Little Andaman Island: Way towards Unnis nallah dam, 27.iv.2006, L. Rasingam 20984; North Nicobars: Katchal Island, West bay, 1.v.1977, P. Chakraborty 5578; South Nicobars: Great Nicobar Islands, 35 km on east-west road, 20.vii.1976, N.P. Balakrishnan 3898; 36.8 km on east-west road, 17.vi.1977, N.P. Balakrishnan 5824.

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# 21. *PANDANUS UNIPAPILLATUS* DENNST.: A NEW RECORD FOR MAHARASHTRA AND GOA, INDIA

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In November 2007, we collected a species from Maharashtra at Sawantwadi (15° 51' 33 N; 73°50' 38 E) of Sindhudurg district and in December 2007 from Goa at Paingen (14°58' 03 N; 74°05' 19 E) of Canacona district. The collected specimen when compared with the authentically identified specimens deposited at the Botanical Survey of India, Western Circle, Pune, was identified as *P. unipapillatus*.

*Pandanus unipapillatus* Dennst. (Pandanaceae) has been reported for the first time for the states of Maharashtra and Goa (Sharma *et al.* 1996; Rao 1986; Kulkarni 1988). In this report, a detailed description of the species is given.

***P. unipapillatus* Dennst.** Schlussel Hortus Malab. 27. (1818).

**Material Examined**: INDIA: Maharashtra (Sindhudurg district, Sawantwadi, 7 km from Sawantwadi towards Londha) female plant, Rahul Zanan 7; Goa Canacona district, Paingen, male plant, Rahul Zanan 5, female, Rahul Zanan 6.

A large shrub or small tree up to 8 m height; more or less erect stem, branching near top with a few prop roots at base. Leaves up to 1.5-2 m x 3-5 cm, margin with sharp curved prickles and midrib prickly along its whole length. 7-8 spines on midrib (per 10 cm), spines 3 mm long, 15-16 on margin (per 10 cm) in three rows, leaf colour deep to light green.

Male inflorescence ephemeral, fragrant, terminal with yellowish 10-12 bracts; spikes up to 12-20 cm long and dense, stemonophore 3-6 mm long; stamen 5-8 mm long with free up to 1 mm long filament; anther 3-5 mm long. Female inflorescence terminal, bracteate, 6-8 bracts of variable length; solitary, oblong-rounded 25-30 cm x 18-20 cm, carpel simple, hexagonal, 4.5 cm long, 1 cm in diameter, single forked, style 1 cm long. Grows at the border of paddy fields and along the bank of streams.

**Flowering & Fruiting:** Fl.: August to October, Fr.: September to December.

**Distribution**: INDIA: Karnataka, Kerala, Tamil Nadu, Maharashtra and Goa.

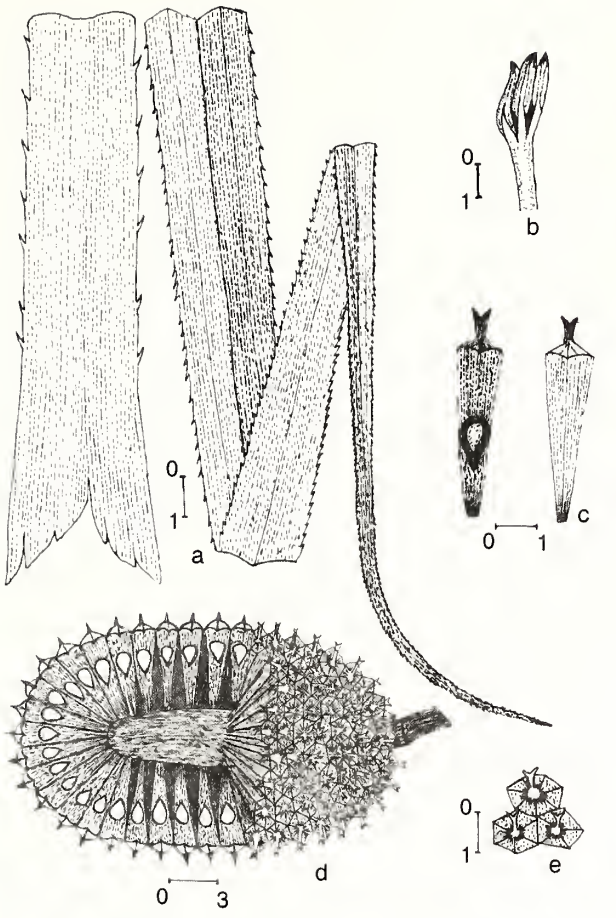


Fig. 1 (a-e): *Pandanus unipapillatus* Dennst.
a. Leaf; b. Androphore; c. Fruit; d. Carpel; e. Bilobed style

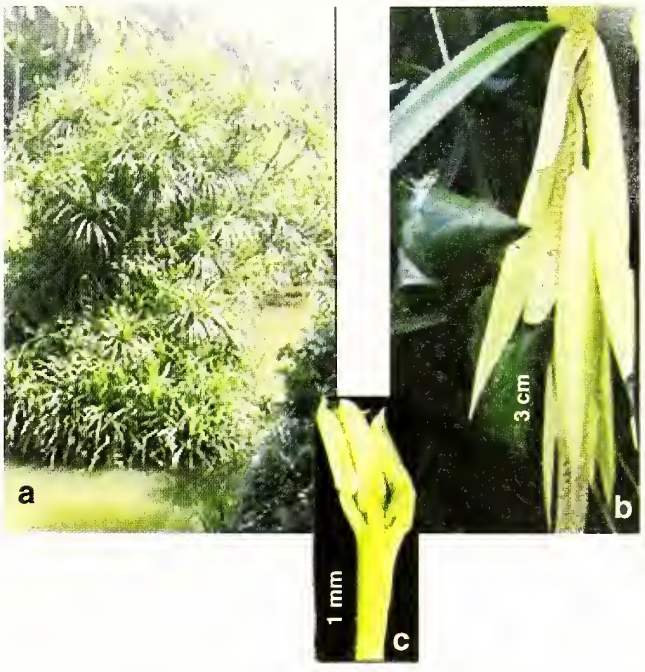


Fig. 2 (a-c): *Pandanus unipapillatus* Dennst.
a. Habit; b. Male inflorescence; c. Androphore

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